U.S. Department of Energy
Technical Qualification Program

Occupational Safety Qualification Standard

Study Guide

Section 1.0
General Technical

April 1996

Competency 1.1 **Occupational safety personnel shall demonstrate a working level knowledge of electricity and electrical hazards to enable them to develop, implement, and evaluate an electrical safety program.**

1. Supporting Knowledge and Skills

a. Discuss general terminology associated with electricity and electrical hazards.

b. Discuss specific terminology applicable to:
- Measurement of electricity
- Power systems
- Electrical distribution systems
- Protective devices

c. Discuss the major safety concerns and appropriate control measures for working on or near electrical equipment.

d. Discuss the use, function, and appropriate application of personal protective equipment (PPE) designed to protect workers from identified electrical hazards.

e. Identify necessary training required for those employees who face a risk of electric shock.

f. For a given workplace scenario, identify the specific safety-related work practices consistent with the nature and extent of the associated electrical hazards.

g. Discuss the appropriate first aid procedures for electrical shock.

h. Identify and discuss the application and function of the major safety requirements and protective devices associated with electrical equipment and wiring in locations which are classified as hazardous.

i. For a given process, operation, or piece of equipment, identify potential electrical hazards; locate, interpret, and apply the requisite requirements and/or standards; and recommend suitable or mandated control measures.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Review DOE-HDBK-1011/1-92, *DOE Fundamentals Handbook, Electrical Science,* Vol. 1 of 4.

EXERCISE 1.1-A Define Voltage, Current (Amperes), and Resistance.

EXERCISE 1.1-B Discuss the mathematical relationship of voltage, current, and resistance as applied to electrical circuitry.

EXERCISE 1.1-C Define impedance for an AC circuit.

Read DOE Order 5480.19, *Conduct of Operations,* Attachment I, Chapters VIII and IX.

EXERCISE 1.1-D Referring to DOE Order 5480.19, Attachment I, discuss the major safety concerns and appropriate control measures for working on or near electrical equipment.

EXERCISE 1.1-E Scenario: An electrician was changing fuses in a 480-volt fused disconnect. As part of procedures, he had turned a switch mechanism to the "off" position and proceeded with his work. While replacing the fuses, his right hand contacted the bottom current-carrying section of the fuse, causing an arc and knocking him unconscious. A supervisor at the scene moved the electrician away from the circuit and administered CPR.

Question: What safe work rules were violated here?

EXERCISE 1.1-F Discuss the mathematical relationship of power (P), voltage (E), and current (I).

EXERCISE 1.1-G What is the purpose(s) of grounding an electrical circuit or system?

EXERCISE 1.1-H What is the purpose(s) of grounding electrical equipment?

Read 29 CFR 1910.333, "Selection and Use of Work Practices."

EXERCISE 1.1-I Scenario: An incident occurred where a worker used an ungrounded drill while drilling a hole through a penetration seal. The worker knew there was a hidden live wire behind the penetration seal, but he believed that the wire could be avoided during the drilling operation. The bit struck the wire and an electrical current passed through the worker's left hand and went to ground through his left biceps.

Question: What violations occurred in the situation and how could they have been avoided?

Read 29 CFR 1910, Subpart I (Sections 132-137).

EXERCISE 1.1-J Who is allowed to perform repairs on electrical circuits and systems?

EXERCISE 1.1-K What institutional standards are cited for Personal Protective Equipment to protect against electrical shock?

Read 29 CFR 1910.332, "Training"

EXERCISE 1.1-L Referring to 29 CFR 1910.332, what training is required for those employees who face a risk of electric shock?

Read DOE/ID-10600, Electrical Safety Guidelines, Section 5.4.5, Electrical Equipment for Class I, II, and III Areas, and Section 5.4.6, Seals and Drains.

EXERCISE 1.1-M Why are seals required in conduit and cable systems?

EXERCISE 1.1-N Describe the purpose of a Type EZD drain seal fittings.

Read 29 CFR 1910.335, "Safeguards for Personnel Protection."

EXERCISE 1.1-O Referring to 29 CFR 1910.335, what are the alerting techniques used to warn and protect employees from electrical hazards?

3. Summary

Identification and acknowledgment of electrical hazards in the work place is the first step in developing an electrical safety program. Once identified, precautions must be put into place to prevent electric shock to the worker. Precautions include design factors for equipment or spaces, or Personal Protective Equipment that ranges from rubber gloves, insulating, mats, and blankets to the specialized tools used. All must be considered when analyzing an electrical safety program.

While the references for this study guide have been limited for ease of study, other references also apply to electrical safety. They include 29 CFR 1927, Subpart K, the National Electrical Code, ANSI/NFPA 70-1990 (NEC), and the *Occupational Safety Observer*, published by the Office of Safety and Assurance.

4. Exercise Solutions

EXERCISE 1.1-A Define Voltage, Current (Amperes), and Resistance.

ANSWER 1.1-A Voltage (E,v) is the electromotive force or pressure required to deliver energy to do the work. Current (I,a) is the component that does the work. Resistance (R) restricts or is the opposition to current flow.

EXERCISE 1.1-B Discuss the mathematical relationship of voltage, current, and resistance as applied to electrical circuitry.

ANSWER 1.1-B E=IxR, I=E/R, and R=E/I, where E=voltage, I=current, and R=resistance.

EXERCISE 1.1-C Define impedance for an AC circuit.

ANSWER 1.1-C Impedance is the opposition to a change in current or voltage in an AC

circuit. It is the sum of resistance and reactance in an AC circuit.

EXERCISE 1.1-D Referring to DOE Order 5480.19, Attachment I, discuss the major safety concerns and appropriate control measures for working on or near electrical equipment.

ANSWER 1.1-D "It is imperative that equipment and systems in a DOE facility be properly controlled. Not only must the operating shift be aware of how equipment ans systems will function for operational purposes, but in order to satisfy the design bases and the operational limits, the proper component, equipment, and system configurations must be established and maintained." From: Attachment I (Chapter VIII, Discussion)

"If there is a potential for equipment damage or injury during equipment operation, servicing, maintenance, or modification activities due to inadvertent activation of equipment, a facility Lockout/Tagout program should be established and used. The Lockout/Tagout program should provide for independent verification of the removal from service and the restoration to service of safety-related and other facility equipment." From: Attachment I (Chapter IX, Introduction)

EXERCISE 1.1-E

Scenario: An electrician was changing fuses in a 480-volt fused disconnect. As part of procedures, he had turned a switch mechanism to the "off" position and proceeded with his work. While replacing the fuses, his right hand contacted the bottom current-carrying section of the fuse, causing an arc and knocking him unconscious. A supervisor at the scene moved the electrician away from the circuit and administered CPR.

Question: What safe work rules were violated here?

ANSWER 1.1-E The electrician violated 20 CFR 1910.333 by not checking to see if the switching mechanism had disconnected the circuit from the voltage source. Secondly, there should have been a "safety watch" assigned and standing by the electrician performing the work not the supervisor of the area. (Source: U.S. Department of Energy, *Occupational Safety Observer*)

EXERCISE 1.1-F Discuss the mathematical relationship of power (P), voltage (E), and current (I).

ANSWER 1.1-F P=IxE, I=P/E, and E=P/I.

EXERCISE 1.1-G What is the purpose(s) of grounding an electrical circuit or system?

ANSWER 1.1-G
1. To limit excessive voltage from lighting, line surges, and crossovers with high voltage lines,
2. To keep conductor enclosures and noncurrent-carrying metal enclosures and equipment at zero potential (0 v.) to ground, and
3. To facilitate the opening of overcurrent protection devices in case of insulation failures because of faults, short circuits, etc.

EXERCISE 1.1-H What is the purpose(s) of grounding electrical equipment?

ANSWER 1.1-H
1. Limit the voltage to ground (shock voltage) on the exposed noncurrent-carrying metal parts of equipment raceways and other conductor enclosures in case of ground faults.
2. Safely conduct ground fault current at sufficient magnitude for fast operation of the circuit overload protection devices.

EXERCISE 1.1-I Scenario: An incident occurred where a worker used an ungrounded drill while drilling a hole through a penetration seal. The worker knew there was a hidden live wire behind the penetration seal, but he believed that the wire could be avoided during the drilling operation. The bit struck the wire and an electrical current passed through the worker's left hand and went to ground through his left biceps.

Question: What violations occurred in the situation and how could they have been avoided?

ANSWER 1.1-I The worker violated OSHA as well as basic, common-sense work practices. Because the position of the wire could not be confirmed, proper safeguards should have been in place for the work area.

29 CFR 1910.333, "Selection and Use of Work Practices." states that "live parts to which an employee may be exposed shall be deenergized

before the employee works on or near them unless the employer can demonstrate that a greater hazard or extreme operational difficulty would result." If the circuit could not be deenergized, then safety practices described in 20 CFR 1910.333(c) should be used.

20 CFR 1910.333(c) applies to all employees who may be exposed to hazardous energized parts. Only qualified workers are allowed to work on electrical equipment or circuits that have not been deenergized. These workers must be familiar with and use the proper PPE, insulating and shielding materials, and insulated tools.

The circuit should have been deenergized with lock and tags in place. Grounded or double insulated power tools should have been utilized and insulating mats, gloves, and other protectors should have been used. (Ref: U.S. Department of Energy, *Occupational Safety Observer*)

EXERCISE 1.1-J Who is allowed to perform repairs on electrical circuits and systems?

ANSWER 1.1-J Only qualified persons (or someone in training and under the direct supervision of a qualified person) shall perform electrical repairs.

EXERCISE 1.1-K What institutional standards are cited for Personal Protective Equipment to protect against electrical shock?

ANSWER 1.1-K The standards of the American National Standards Institute (ANSI).

EXERCISE 1.1-L Referring to 29 CFR 1910.332, what training is required for those employees who face a risk of electric shock?

ANSWER 1.1-L Below is a summary of training requirements found in 29 CFR 1910.332, "Training" of Subpart S, *Electrical*:

- The training requirements apply to employees who face a risk of electric shock that is not reduced to a safe level by the electrical installation requirements of 1910.303 through 1910.308.
- Employees who face such a risk are required to be trained. The CFR targets occupations requiring training in Table S-4. Other employees who also may reasonably be expected to face a

comparable risk of injury due to electric shock or other electrical hazards must also be trained.

- Qualified persons (i.e. those permitted to work on or near exposed energized parts) shall, at a minimum, be trained in and familiar with the following:
  - The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment
  - The skills and techniques necessary to determine the nominal voltage of exposed live parts
  - The clearance distances specified in 1910.333(c) and the corresponding voltages to which the qualified person will be exposed.
- The degree of training provided depends on the risk to the employee.

EXERCISE 1.1-M Why are seals required in conduit and cable systems?

ANSWER 1.1-M "...to minimize the passage of gases or vapors from one portion of the system to another portion. And ...to keep from transmitting an explosion or to keep ignition from traveling between sections of the system."

EXERCISE 1.1-N Describe the purpose of a Type EZD drain seal fittings.

ANSWER 1.1-N These fittings prevent accumulations of water above the seal.

EXERCISE 1.1-O Referring to 29 CFR 1910.335, what are the alerting techniques used to warn and protect employees from electrical hazards?

ANSWER 1.1-O "The following alerting techniques shall be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:
(1) Safety signs and tags. Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them, as required by 1910.145.
(2) Barricades. Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit

parts. Conductive barricades may not be used where they might cause an electrical contact hazard.
(3) Attendants. If signs and barricades do not provide sufficient warning and protection from electrical." From: 29 CFR 1910.335

Competency 1.6 **Occupational safety personnel shall demonstrate a working level knowledge of ergonomic hazards and the elimination or control of them.**

1. Supporting Knowledge and Skills

a. Discuss the basic terminology associated with ergonomics.

b. Describe ergonomic considerations that must be addressed when evaluating new or existing jobs, processes, or operations, and identify appropriate methods for the elimination or control of ergonomic hazards.

c. Explain the application of "signal risk factors" with regard to ergonomic hazards.

d. Discuss the methodology for analyzing lifting tasks.

e. Discuss the significance of repetitive motions and tasks.

f. Discuss the importance of worker interfaces with operational equipment.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Read the summary to this study guide and the National Safety Council *Fundamentals of Industrial* Hygiene, 4th edition, pages 7-24 and 29-31.

NOTE: Both the Department of Energy (DOE) and the Occupational Safety and Health Administration (OSHA) have draft ergonomics standards available for review. Neither are final, approved, or complete, but they do provide a look at the direction the Federal government is taking in ergonomics policy. The DOE version is available through DOE Office of Environment, Safety, and Health Technical Information Services at: gopher://nattie.eh.doe.gov:2011/11/. standards or by calling 301-903-9765. The OSHA version may be downloaded from the following World Wide Web site: http://www.osha-slc.gov/misc/ergo_draft.html

EXERCISE 1.6-A Define the following terms as they relate to ergonomics.
NOTE: Since ergonomics borrows from several disciplines, this is a representative sampling of common terms. Refer to the glossary (Appendix A) for a more extensive listing of occupational safety terms.

- Administrative controls
- Awkward posture
- Control the job or controlled job
- Engineering controls
- Equipment
- Ergonomics
- Fixed posture
- Incidence rate
- Job
- Lower extremity
- Package
- Personal protective equipment
- Restrictions
- Severity rate
- Tasks
- Unassisted frequent or forceful manual handling
- Upper extremity
- Vibration
- Work methods
- Workplace
- Workplace risk factors
- Work-related musculoskeletal disorder

EXERCISE 1.6-B Describe ergonomic considerations that must be addressed when evaluating new or existing jobs, processes, or operations, and identify appropriate methods for the elimination or control of

ergonomic hazards.

EXERCISE 1.6-C Identify and explain the application of the five "signal risk factors" with regard to ergonomic hazards.

EXERCISE 1.6-D Where can data requirements and procedures for using the National Institute for Occupational Safety and Health's (NIOSH's) revised lifting equation be found?

EXERCISE 1.6-E Discuss the significance of repetitive motions and tasks.

EXERCISE 1.6-F Referring to *Fundamentals of Industrial Hygiene*, Chapter 13, "Ergonomics," discuss workplace design and identify the six general principles to follow in the preparation of a design for a specific workplace.

3. Summary

Work systems (see Figure 1.6-1) require a balance between technology (tools and equipment), the organization, the environment, the job, and the individual (Smith and Sainfort 1988). When any one of the basic connections between these elements is not functioning optimally, the work system is impaired.

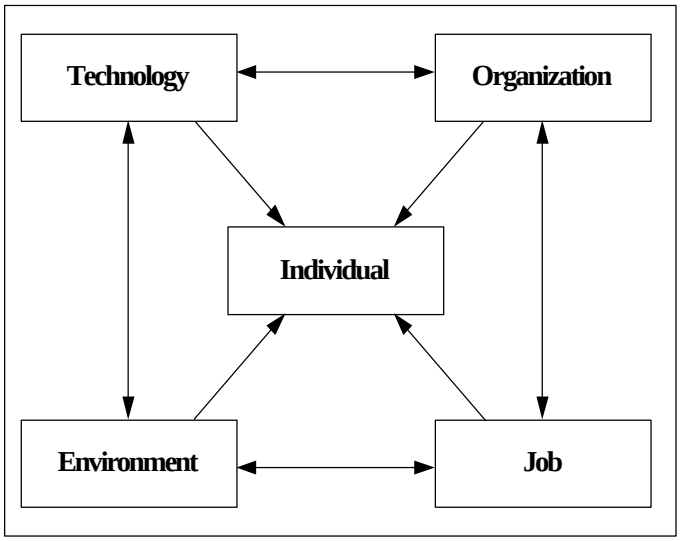

Figure 1.6-1 Work Systems

Changes in attributes such as productivity and quality can reveal work system impairment. Productivity can be influenced by malfunctioning tools and equipment, employee turnover, and problems that may arise due to the physical demands employees face in performing their jobs. Likewise, malfunctioning tools and equipment, insufficient training, lack of feedback, and unrealistic production requirements can affect quality. The occurrence of work-related musculoskeletal disorders can also indicate work system imbalance. As reflected in Figure 1.6-1, an individual may be affected by technology (e.g., semiautomation that increases repetitive motions), environmental factors (e.g., poor lighting that leads to awkward postures or heat that contributes to fatigue), or physical demands that exceed the individual's capabilities. If signs of system imbalance are present, employers must take steps to identify the causes and implement the controls needed to bring the system back into balance.

An imbalance can result in a "problem job," which can lead to musculoskeletal disorder. Ergonomic principles can be used to prevent or resolve problem jobs that result from a mismatch between the worker and the work system.

Ergonomics involves performance of the following tasks:

- Recognizing where the opportunities exist to reduce or eliminate risk factors associated with musculoskeletal disorders (i.e., new and existing jobs or processes)
- Using the problem-solving process to identify causes of system imbalance (e.g., risk factors associated with musculoskeletal disorders)
- Performing a more detailed job analysis to identify the root cause of ergonomic problems in complex tasks
- Analyzing manual handling tasks, such as lifting, lowering, pushing, pulling, twisting (torquing) and carrying
- Identifying controls, the different classifications of controls, and the different opportunities for controls for new and existing jobs and processes
- Identifying procedures for evaluating, selecting, implementing, and measuring controls

NOTE: *Specific information or analysis should be obtained through an expert in ergonomics.*

4. Exercise Solutions

EXERCISE 1.6-A Define the following terms as they apply to ergonomics.
NOTE: Since ergonomics borrows from several disciplines, this is a representative sampling of common terms.

ANSWER 1.6-A

Terms Related to Ergonomics	
Term	**Definition**
Administrative controls	Any procedures that significantly limit daily exposure by control or modification of the work schedule or manner in which work is performed. Administrative controls include, but are not limited to, job rotation, use of rest breaks or alternative tasks, job enlargement to increase task variability, redesign of work methods, and adjustment of work pace to reduce the number of repetitions.
Awkward posture	A deviation from the neutral position of any particular joint. Examples include, but are not limited to, twisting, bending, kneeling, squatting, and stooping.
Control the job or controlled job	To implement control measures that reduce or prevent employee exposure to workplace risk factors.
Engineering controls	Physical changes to workstations, equipment, materials, production facilities, or any other relevant aspect of the work environment that reduce or prevent exposure to workplace risk factors.
Equipment	Tools, machines, vehicles, devices, furniture, installations, and other components in the work system.
Ergonomics	The field of study that seeks to fit the job to the person, rather than the person to the job. This is achieved by the evaluation and design of workplaces, environments, jobs, tasks, equipment, and processes in relationship to human capabilities and interactions in the workplace.
Fixed posture	Prolonged muscle contraction without movement, such as maintaining an unsupported posture or prolonged gripping of a tool.
Incidence rate	The number of new work-related musculoskeletal disorders that occur during a year per 100 full-time equivalent workers. Incidence rates are calculated as follows: (number of new work-related musculoskeletal disorders) x (200,000 work hours or 100 full-time equivalent workers)/ (work hours per year or total number of full-time equivalent workers)

Terms Related to Ergonomics	
Term	**Definition**
Job	The performance of a series of tasks in order to reach a goal or defined end product, including a job assignment to complete specific tasks.
Lower extremity	The hip, thigh, knee, leg, ankle, and/or foot.
Package	Material(s) or object in a container where the contents are not known and the weight cannot be ascertained by the handling employee, e.g., a cardboard box containing cans of paint or a suitcase in baggage handling.
Personal protective equipment	Devices such as, but not limited to, corrective lenses for work with video display units, gloves, or padding, worn on or attached to the body, which are used for the purpose of controlling workplace risk factors.
Restrictions	Any limitation placed on the manner in which an employee performs a job or work tasks during the recovery period. Restrictions refer collectively to any of the following: alternative duty assignment, alternative work, light duty, job modifications, job restrictions, and modified duty.
Severity rate	The number of lost work days due to work-related musculoskeletal disorders occurring in a year per 100 full-time equivalent workers. Severity rates are calculated as follows: (number of lost workdays) x (200,000 hours or 100 full-time equivalent workers)/(work hours per year or number of full-time equivalent workers).
Task	A subunit of a job or the group of activities that must be performed to accomplish the work objective or the job.
Unassisted frequent or forceful manual handling	Lifting, lowering, carrying, handling or pushing/pulling animals, people, heavy objects, equipment, or tools without assistance from mechanical devices.
Upper extremity	The hand, wrist, elbow, arm, shoulder and/or neck.

Terms Related to Ergonomics	
Term	**Definition**
Vibration	The oscillatory motion of a physical body. Localized (segmental) vibration, such as hand-arm vibration, is produced by contact with powered tools or equipment, or vibrating structures. Whole-body vibration exposure occurs while standing or seated in vibrating environments or objects, such as trucks or heavy machinery, or while using heavy equipment, such as jackhammers.
Work methods	The physical methods used to perform the tasks of a job, such as reaching, gripping, using tools and equipment, or discarding objects.
Workplace	An establishment, job site, or project, at one geographical location.
Workplace risk factors	Actions in the workplace, workplace conditions, or a combination thereof, that may cause or aggravate a work-related musculoskeletal disorder. Workplace risk factors include, but are not limited to, repetitive, forceful, or prolonged exertions; frequent or heavy lifting; pushing, pulling, or carrying of heavy objects; a fixed or awkward work posture; contact stress; localized or whole-body vibration, cold temperatures; and poor lighting (leading to awkward postures). These workplace risk factors can be intensified by work organization characteristics, such as inadequate work-rest cycles, excessive work pace and/or duration, unaccustomed work, lack of task variability, machine-paced work, and piece rate.
Work-related musculoskeletal disorder	An injury or illness of the muscles, tendons, ligaments, peripheral nerves, joints, cartilage (including intervertebral discs), bones, and/or supporting blood vessels in either the upper or lower extremities, or back, which is associated with musculoskeletal disorder workplace risk factors and which is not the result of acute or instantaneous events (e.g., slips or falls). Classifications such as, but not limited to, cumulative trauma disorders, repetitive strain injuries or illnesses, repetitive motion injuries or illnesses, and repetitive stress injuries or illnesses are included in this definition.

EXERCISE 1.6-B Describe ergonomic considerations that must be addressed when evaluating new or existing jobs, processes, or operations, and identify appropriate methods for the elimination or control of ergonomic hazards.

ANSWER 1.6-B Designers, suppliers, and manufacturers who provide assistance in identifying and applying ergonomic design principles should be consulted when evaluating new jobs in order to prevent new problems from being created. The use of workplace risk factor checklists should assist the occupational safety professional in assessing existing jobs or changes in existing jobs. Appropriate methods for elimination or control of ergonomic hazards will depend on the specific situation. Refer to an ergonomics specialist for assistance.

EXERCISE 1.6-C Identify and describe the application of the five "signal risk factors" with regard to ergonomic hazards.

ANSWER 1.6-C The five "signal risk factors" are as follows;
NOTE: The information below is found in the OSHA draft ergonomics standard.

Five Signal Risk Factors	
Signal Risk Factor	**Description**
Performance of the same motion or motion pattern every few seconds	Frequent repetitions of the same motions stress the body parts involved. The repetition may be of a "pattern" where several motions get repeated every few seconds, e.g., completion of the task may involve three steps that get repeated in sequence every few seconds. Much assembly line work involves repetition for long periods of time. When this repetition occurs for more than two hours at a time during the work shift without a break, the body may not have time to sufficiently rest the body parts that are being repeatedly stressed.
A fixed or awkward work posture (for example, overhead work, twisted or bent back, bent wrist, kneeling, stooping, or squatting)	Holding body parts in fixed or awkward postures for more than two hours during a work shift also creates excess stress that can cause or aggravate work-related musculoskeletal disorders.

Five Signal Risk Factors	
Signal Risk Factor	**Description**
Use of vibrating or impact tools or equipment	Stress on the body due to vibration or impact of tools or equipment has also been shown to cause work-related musculoskeletal disorders. These may be hand-held power tools, such as a power sander, or large pieces of equipment that are being driven, such as forklifts.
Forceful hand exertions	-- No description available --
Unassisted frequent or forceful manual lifting	Many jobs require workers to lift, carry, or otherwise handle objects. Generally speaking, the heavier the object is, the greater risk to the employees handling it. However, frequency of lifting or handling is also a concern, as are the size and shape of the objects, the distance they have to be carried, and the height from which or to which they have to be lifted.

EXERCISE 1.6-D Where can data requirements and procedures for using NIOSH's revised lifting equation be found?

ANSWER 1.6-D NIOSH developed *Applications Manual for the Revised NIOSH Lifting Equation* (DHHS [NIOSH] Pub. No. 94110). The applications manual contains new procedures for assessing multitask lifting jobs and a series of example problems to demonstrate use of the revised lifting equation.

EXERCISE 1.6-E Discuss the significance of repetitive motions and tasks.

ANSWER 1.6-E *Repetition* refers to a task or series of motions that is performed over and over again, with little variation. If tasks or motions are repeated frequently (e.g., every few seconds), fatigue and muscle-tendon strain can accumulate, which can result in permanent tissue damage. Tendons and muscles can often recover from the effects of stretching or forceful exertions if sufficient time is allotted between exertions. Frequent repetition of the same work activities can also exacerbate the effects of awkward postures and forceful exertions.

EXERCISE 1.6-F Referring to the National Safety Council's *Fundamentals of Industrial Hygiene*, Chapter 13, "Ergonomics," discuss workplace design and identify the six general principles to follow in the preparation of a design for a specific workplace.

ANSWER 1.6-F The objective in designing a workstation is to provide an environment free of unnecessary stresses. Productivity will suffer if the operator is uncomfortable or if controls are awkwardly placed. Because of the many factors affecting the interaction between operators and the equipment they control, it may not be possible to provide an optimum environment in all respects. However, careful consideration of the capacities and limitations of the user population and of the system performance requirements will lead to the best possible compromises.

Six general rules to follow in the preparation of a design for a specific workplace are as follows:

1. Plan the whole, then the detail.
2. Plan the ideal, then the practical.
3. Plan the process and equipment around the system requirements.
4. Plan the layout around the process and equipment.
5. Plan the final enclosure around the layout.
6. Use mock-ups to evaluate alternative layouts and to check the final layout.

Competency 1.7 **Occupational safety personnel shall demonstrate a working level knowledge of safety precautions and hazards associated with workplace chemicals.**

1. Supporting Knowledge and Skills

a. Discuss the hazards associated with the following types of chemicals:
- Corrosives
- Flammable, combustible, and explosive materials
- Oxidizers
- Cryogenic liquids
- Toxic chemicals
- Chemicals that displace oxygen

b. Discuss the terminology associated with the effects of toxic chemicals.

c. Describe the general safety precautions that must be implemented or observed during the use, handling, storage, transportation, and disposal of each type of hazardous chemical listed above.

d. Describe the safety precautions specific to the use, handling, storage, and disposal of flammable and combustible liquids.

e. Discuss the hazards associated with confined space entry and describe proper confined space entry precautions and procedures.

f. Discuss the hazards associated with chemical incompatibilities and the need for segregation and containment.

g. Discuss conditions under which the use of personal protective equipment (PPE) is acceptable in terms of the hierarchy of control measures and is appropriate for the hazard present.

h. Discuss first aid and emergency response considerations for operations involving hazardous chemicals.

i. Discuss the methods by which toxic compounds may enter the body and the control mechanisms available to block these routes of entry.

j. Analyze a given process or operation to identify potential chemical hazards and appropriate control measures.

k. Describe the general considerations for the storage and use of different classes of explosives and blasting agents, including the construction, capacity, and placement of facilities or operations.

l. Discuss the use of, and considerations regarding, chemical monitoring and sampling techniques.

m. Discuss the application of the major elements of a Hazard Communication Program, Laboratory Safety Program, and Process Safety Management Program.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Scan the tables of contents in 29 *Code of Federal Regulations* (CFR) 1910.119, "Process Safety Management of Highly Hazardous Chemicals," and the NIOSH *Pocket Guide to Chemical Hazards*.

EXERCISE 1.7-A Referring to 29 CFR 1910.119, Appendix A, and the *NIOSH Pocket Guide to Chemical Hazards*, determine the following for the hazardous chemical phosgene:

1. Its threshold quantity (the amount necessary to be covered by 29 CFR 1910.119)
2. Its physical characteristics

3. The symptoms, if inhaled
4. The first aid for contact to the eyes

EXERCISE 1.7-B Referring to 29 CFR 1910.119, Appendix A, and the *NIOSH Pocket Guide to Chemical Hazards*, for the hazardous chemical pentachlorophenol, what is the immediately dangerous to life or health (IDLH) concentration? What should pentachlorophenol be stored away from?

EXERCISE 1.7-C Referring to 29 CFR 1910.119, what are the general elements of a process safety management program that must be implemented when dealing with a highly hazardous chemical?

Read 29 CFR 1910.120 (g), "Engineering controls, work practices, and personal protective equipment for employee protection."

EXERCISE 1.7-D Referring to 29 CFR 1910.120 (g), under what general circumstances would the PPE be used as a control measure to reduce and maintain to or below the permissible exposure limits or dose limits?

Read 29 CFR 1910.1200 (e), "Written hazard communication program."

EXERCISE 1.7-E Referring to 29 CFR 1910.1200 (e), what are the general elements of an employer's hazard communication program?

Scan 29 CFR 1910.1450, Appendix A.

EXERCISE 1.7-F Referring to 29 CFR 1910.1450, Appendix A, what are the general components of a chemical hygiene plan?

Scan 29 CFR 1910.109, "Explosives and Blasting Agents."

EXERCISE 1.7-G Referring to 29 CFR 1910.109, what are the time and contents of the required advance notification for the blaster to inform utilities (gas, electric, water, fire alarm, telephone, telegraph, and steam) of blasting in their vicinity?

Read 29 CFR 1910.146 (a) and (b), "Permit-required Confined Spaces," and **scan** National Institute for Occupational Safety and Health (NIOSH) Pub. No. 80-106, *Criteria for Recommended Standard: Working in Confined Spaces*, and American National Standards Institute (ANSI) Z88.2-1980, *Practices for Respiratory Protection*.

EXERCISE 1.7-H Referring to 29 CFR 1910.146 (a) and (b), what are the criteria for determining whether a confined space is a permit-required confined space?

EXERCISE 1.7-I Address the following confined space hazard considerations for construction operations:

- Describe the characteristics of a confined space hazard
- Identify potential construction related confined space locations
- Identify and discuss the application of confined space entry procedures

Scan 29 CFR 1910.106, "Flammable and Combustible Liquids," and Occupational Safety and Health Administration (OSHA) Standard 2202, Section 21, "Flammable and Combustible Liquids."

EXERCISE 1.7-J Referring to 29 CFR 1910.106, what is the difference between combustible liquids and flammable liquids?

EXERCISE 1.7-K Referring to OSHA Standard 2202, describe the general safety precautions regarding the use, handling, and storage of flammable and combustible materials.

Read Chapter 1 of the *Fundamentals of Industrial Hygiene*.

EXERCISE 1.7-L What are the primary routes and methods of the entry of hazardous chemicals into the human body?

Read 29 CFR 1910.120 (q), "Emergency Response Hazardous Substance Releases."

EXERCISE 1.7-M Referring to 29 CFR 1910.120 (q), what are the minimum elements that must be addressed in an emergency response plan?

3. Summary

(From *Fundamentals of Industrial Hygiene*, page 9.)

The majority of the occupational health hazards arise from inhaling chemical agents in the form of vapors, gases, dusts, fumes, and mists, or by skin contact with these materials. The degree of risk of handling a given substance depends on the magnitude and duration of exposure. The required information about these chemical hazards can be obtained from the Material Safety Data Sheet (MSDS), which must be supplied by the chemical manufacturer or importer to the purchaser for all hazardous materials that are subject to 29 CFR 1200.

Explosives are those substances, mixtures, or compounds capable of entering a combustion reaction so rapidly and violently as to cause an explosion. Corrosives are capable of destroying living tissue and have a destructive effect on other substances, particularly on combustible materials; this effect can result in a fire or explosion. Flammable liquids are those liquids with a flash point of 38°C (100°F) or less, although those with higher flash points can be both combustible and dangerous. Toxic chemicals are those gases, liquids, or solids which, through their chemical properties, can produce injurious or lethal effects upon contact with body cells. Oxidizing materials are those chemicals which will decompose readily under certain conditions to yield oxygen. They may cause a fire in contact with combustible materials and can react violently with water, or when involved in a fire. Dangerous gases are those gases which can cause lethal or injurious effects and damage to property by their toxic, corrosive, flammable, or explosive physical and chemical properties.

The toxicity of a material is not synonymous with its being a health hazard. *Toxicity* is the capacity of a material to produce injury or harm. *Hazard* is the possibility that exposure to a material will cause injury when a specific quantity is used under certain conditions. The key elements to be considered when evaluating a health hazard are listed below:

- How much of the material must be in contact with a body cell, and for how long, to produce injury?
- What is the probability that the material will be absorbed or come in contact with body cells?
- What is the rate of generation of airborne contaminants?
- What control measures are in use?

The effects of exposure to a substance depend on the dose, rate, physical state of the substance, temperature, site of absorption, diet, and general state of a person's health.

4. Exercise Solutions

EXERCISE 1.7-A Referring to 29 CFR 1910.119, Appendix A, and the *NIOSH Pocket Guide to Chemical Hazards*, determine the following for the hazardous chemical phosgene:

1. Its threshold quantity (the amount necessary to be covered by 29 CFR 1910.119)
2. Its physical characteristics
3. The symptoms if inhaled
4. The first aid for contact to the eyes

ANSWER 1.7-A

1. 100 pounds
2. Colorless gas with suffocating odor like musty hay
3. Irritated eyes, dry burning throat, cough, vomiting
4. Wash the eye immediately and then get medical attention immediately

EXERCISE 1.7-B Referring to 29 CFR 1910.119, Appendix A, and the *NIOSH Pocket Guide to Chemical Hazards*, for the hazardous chemical pentachlorophenol, what is the immediately dangerous to life or health (IDLH) concentration? What should pentachlorophenol be stored away from?

ANSWER 1.7-B

1. IDLH = 25 mg/m^3
2. strong oxidizers, acids, alkalis

EXERCISE 1.7-C Referring to 29 CFR 1910.119, what are the general elements of a process safety management program that must be implemented when dealing with a highly hazardous chemical?

ANSWER 1.7-C

1. Hazardous material analysis communications to employees
2. Safety information pertaining to the chemicals, the technology of the process, and equipment used in the process
3. Process hazard analyses conducted
4. Operating procedures
5. Training
6. Pre-startup safety review
7. Mechanical integrity

8. Change and modification control
9. Incident investigation
10. Emergency planning and response

EXERCISE 1.7-D Referring to 29 CFR 1910.120 (g), under what general circumstances would the PPE be used as a control measure to reduce and maintain to or below the permissible exposure limits or dose limits?

ANSWER 1.7-D Whenever engineering controls and work practices are not feasible or not required.

EXERCISE 1.7-E Referring to 29 CFR 1910.1200 (e), what are the general elements of an employer's hazard communication program?

ANSWER 1.7-E
1. A list of the hazardous chemicals known to be present
2. The labeling of all hazardous chemical containers
3. A material safety data sheet (MSDS) for each hazardous chemical
4. Employee information and training

EXERCISE 1.7-F Referring to 29 CFR 1910.1450, Appendix A, what are the general components of a chemical hygiene plan?

ANSWER 1.7-F
1. Basic rules and procedures
2. Chemical procurement, distribution, and storage
3. Environmental monitoring
4. Housekeeping, maintenance, and inspection
5. Medical program
6. Personal protective apparel and equipment
7. Records
8. Signs and labels
9. Spills and accidents
10. Training and information
11. Waste disposal

EXERCISE 1.7-G Referring to 29 CFR 1910.109, what are the time and contents of the required advance notification for the blaster to inform utilities (gas, electric, water, fire alarm, telephone, telegraph, and steam) of blasting in their vicinity?

ANSWER 1.7-G
1. 24 hours in advance
2. Location and intended time of the blasting

EXERCISE 1.7-H Referring to 29 CFR 1910.146 (a) and (b), what are the criteria for determining whether a confined space is a permit-required confined space?

ANSWER 1.7-H A permit-required confined space has one or more of the following characteristics:
1. Contains or has a potential to contain a hazardous atmosphere
2. Contains a material that has the potential for engulfing an entrant
3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section
4. Contains any other recognized serious safety or health hazard

EXERCISE 1.7-I Address the following confined space hazard considerations for construction operations:
- Describe the characteristics of a confined space hazard
- Identify potential construction related confined space locations
- Identify and discuss the application of confined space entry procedures

ANSWER 1.7-I
- A permit-required confined space has one or more of the following characteristics:
  - Contains or has a potential to contain a hazardous atmosphere
  - Contains a material that has the potential for engulfing an entrant
  - Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section
  - Contains any other recognized serious safety or health hazard

- There are numerous possible answers to this question. These include, but are not limited to, the following:
  - Manholes
  - Stacks
  - Storage tanks
  - Trailers
  - Tank cars
  - Vats
  - Vessels
  - Pits
  - Sumps
  - Hoppers
  - Bins
  - Trenches
  - Rooms
  - Tunnels
  - Pipes
- The following steps for entry into a confined space are generic and, therefore, apply to many confined space entries. However, these steps may be altered by site or facility procedures.
  - Complete the initial portion of a confined space entry permit
  - Confirm or perform training to establish personnel proficiency in the duties required
  - Test the atmosphere (O_2, explosive limits, toxic atmosphere) as required
  - Set up atmospheric monitoring to be performed throughout the entry
  - If a hazardous atmosphere is detected, evaluate to determine the cause
  - Take measures to protect employees before entry is made
  - Require proper respiratory equipment if needed
  - Complete the confined space entry permit
  - Allow entry only after all requirements of the permit are met and it is reviewed and signed by the entry supervisor or job leader.

EXERCISE 1.7-J Referring to 29 CFR 1910.106, what is the difference between combustible liquids and flammable liquids?

ANSWER 1.7-J A combustible liquid is any liquid having a flashpoint at or above 100°F (37.8°C) and a flammable liquid is any liquid having a flashpoint below 100°F (37.8°C).

EXERCISE 1.7-K Referring to OSHA Standard 2202, describe the general safety precautions regarding the use, handling, and storage of flammable and combustible materials.

ANSWER 1.7-K From OSHA 2202, Section 21, "Flammable and Combustible Liquids"

" a. Only approved containers and portable tanks shall be used for the storage and handling of flammable and combustible liquids.

b. No more than 25 gallons of flammable or combustible liquids shall be stored in a room outside of an approved storage cabinet. No more than 60 gallons of flammable or 120 gallons of combustible liquids shall be stored in any one storage cabinet. No more than three storage cabinets may be located in a single storage area.

c. Inside storage rooms for flammable and combustible liquids shall be of fire-resistant construction, have self-closing fire doors at all openings, four-inch sills or depressed floors, a ventilation system that provides at least six air changes within the room per hour, and electrical wiring and equipment approved for Class I, Division 1 locations.

d. Storage in containers outside buildings shall not exceed 1,100 gallons in any one pile or area. The storage area shall be graded to divert possible spills away from building or other exposures, or shall be surrounded by a curb or dike. Storage areas shall be located at least 20 feet from any building and shall be free from weeds, debris, and other combustible materials not necessary to the storage.

e. Flammable liquids shall be kept in closed containers when not actually in use.

f. Conspicuous and legible signs prohibiting smoking shall be posted in service and refueling areas."

EXERCISE 1.7-L What are the primary routes and methods of the entry of hazardous chemicals into the human body?

ANSWER 1.7-L

Primary Routes and Methods of Entry	
Route	**Description**
Inhalation	Involves those airborne contaminants that can be inhaled directly into the lungs and can be physically classified as gases, vapors, and particulate matter such as dusts, fumes, smoke, aerosols, and mists.
Absorption	Chemicals can be absorbed through the skin and more rapidly through cut or abraded skin than through intact or unbroken skin. Some substances are absorbed by way of the openings for hair follicles, while others dissolve in the fats and oils of the skin. Some organic chemicals can produce systemic poisoning by direct contact with the skin.
Ingestion	Toxic compounds are capable of being absorbed from the gastrointestinal tract into the blood.

EXERCISE 1.7-M Referring to 29 CFR 1910.120 (q), what are the minimum elements that must be addressed in an emergency response plan?

ANSWER 1.7-M
1. Preemergency planning
2. Personnel roles and responsibilities
3. Emergency recognition and prevention
4. Safe distances and places of refuge
5. Site security and control
6. Evacuation routes and procedures
7. Decontamination procedures

8. Emergency medical treatment and first aid
9. Emergency alerting and response procedures
10. Critique of response and follow-up
11. Personal protective equipment and emergency equipment

Competency 1.8 **Occupational safety personnel shall demonstrate a familiarity level knowledge of the following disciplines that interface with occupational safety:**

- **Health Physics**
- **Industrial Hygiene**
- **Occupational Medicine**
- **Safeguards and Security**
- **Environmental Protection**
- **Nuclear Safety**

1. Supporting Knowledge and Skills

a. Discuss the applicability of occupational safety and health criteria contained in Department of Energy Orders on nuclear safety.

b. Describe the potential impact of nuclear safety requirements on occupational safety matters and discuss the need for coordination between occupational safety professionals and health physicists.

c. Discuss applicable “safety and analysis” and “review system criteria” for nuclear facilities.

d. Discuss the fundamentals of industrial hygiene in terms of:
   - Basic terminology
   - Nature, recognition, evaluation and control of hazards
   - Necessary elements for implementing and maintaining an effective industrial hygiene program

e. Discuss the relationship, and the need for coordination that exists, between the disciplines of: occupational safety; industrial safety; health physics; and, occupational medicine.

f. Discuss the Department's occupational medicine program requirements and their applicability/interface with occupational safety program requirements.

g. Discuss the general requirements of the Department's environmental protection program and describe how these requirements interface with the occupational safety program.

h. Discuss the interface with, and the general requirements for, the Department's Safeguards and Security program.

i. Discuss the interface that exists between occupational safety personnel and safeguards and security personnel, and why this interface is needed.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTES:
- The DOE Orders are in a state of transition. Please refer to the following gopher site for a cross reference of new and old Orders: gopher://VM1.HQADMIN.DOE.GOV:70/00/doemenu1/directiv/251cross.asc
- Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Read paragraph 5. of DOE 5480.1B, *Environment, Safety, and Health (ES&H) Program for Department of Energy Operations,* and paragraph 8. of DOE 5480.5, *Safety of Nuclear Facilities.*

EXERCISE 1.8-A Referring to paragraph 5.d. of DOE 5480.1B, *Environment, Safety, and Health (ES&H) Program for Department of Energy Operations,* what are the functional disciplines or areas that typically comprise ES&H activities at a nuclear facility?

EXERCISE 1.8-B Referring to paragraph 8.f. of DOE 5480.5, *Safety of Nuclear Facilities,* what nuclear facility activities are covered under ES&H codes, standards, and guides?

EXERCISE 1.8-C Referring to paragraph 8.a. of DOE 5480.5, *Safety of Nuclear Facilities,* what specific process is the basis for the identification and control of risks?

Read the Summary section of this study guide and Chapter 1 of *Fundamentals of Industrial Hygiene* (or introductory sections of any other similar textbook).

EXERCISE 1.8-D Referring to *Fundamentals of Industrial Hygiene* (or any other comparable text), list three disciplines that constitute the typical industrial hygiene/occupational health program.

Scan paragraphs 1 through 7.a. of DOE 5480.8A, *Contractor Occupational Medical Program*.

EXERCISE 1.8-E Referring to paragraph 7.a. of DOE 5480.8A, *Contractor Occupational Medical Program*, what is the frequency and the basis that occupational medical physicians must visit each contractor installation?

EXERCISE 1.8-F Referring to paragraph 7.a. of DOE 5480.8A, *Contractor Occupational Medical Program*, how often are DOE and its contractors required to offer all employees a comprehensive health examination?

Scan paragraphs 7 and 8 of DOE 5630.11B, *Safeguards and Security Program*.

EXERCISE 1.8-G Referring to paragraph 8.k. of DOE 5630.11B, *Safeguards and Security Program*, what action must the head of the field element take if operations would result in unacceptable risk to national security or the health and safety of employees?

EXERCISE 1.8-H Referring to paragraph 9 of DOE 5630.11B, *Safeguards and Security Program*, what are some of the actions that may cause ". . .unacceptable risk to national security or the health and safety of DOE and contractor employees. . .?"

EXERCISE 1.8-I How do occupational safety personnel get involved in safeguards and security issues?

Scan paragraphs 3, 4, and 8 and Attachments 1 and 2 of DOE 5480.4, *Environmental Protection, Safety, and Health Protection Standards*.

EXERCISE 1.8-J Referring to Attachments 1 and 2 of DOE 5480.4, list at least three of the general categories of mandatory ES&H standards (that

encompass DOE and non-DOE federal ES&H statutes and/or requirements).

3. Summary

The industrial hygienist is involved with the monitoring and analytical methods required to detect the extent of exposure, and the engineering and other methods used for hazard control. Evaluation of the magnitude of the environmental factors and stresses arising in or from the workplace is done by the industrial hygienist, aided by training, experience, and quantitative measurement of the chemical, physical, ergonomic, or biological stresses.

An effective industrial hygiene program would consist of the application of knowledge to the anticipation and recognition of health hazards arising out of work operations and processes, evaluation, and measurement of the magnitude of the hazard. Occupational health hazards are: 1) conditions that cause legally compensable illnesses, or 2) any conditions in the workplace that impair the health of employees enough to make them lose time from work or to cause significant discomfort.

The occupational health program requires the services of the professional disciplines of the occupational physician, the occupational nurse, and the industrial hygienist, each supported by ancillary safety and health professionals, including industrial toxicologists and health physicists.

4. Exercise Solutions

EXERCISE 1.8-A Referring to paragraph 5.d. of DOE 5480.1B, *Environment, Safety, and Health (ES&H) Program for Department of Energy Operations,* what are the functional disciplines or areas that typically comprise ES&H activities at a nuclear facility?

ANSWER 1.8-A Environmental protection, occupational safety, fire protection, industrial hygiene, health physics, occupational medicine, process and facilities safety, nuclear safety, emergency preparedness, quality assurance, and radioactive and hazardous waste management.

EXERCISE 1.8-B Referring to paragraph 8.f. of DOE 5480.5, *Safety of Nuclear Facilities,* what nuclear facility activities are covered under ES&H

codes, standards, and guides?

ANSWER 1.8-B Siting, design, construction, modification, operation, maintenance, deactivation, decontamination, and decommissioning.

EXERCISE 1.8-C Referring to paragraph 8.a. of DOE 5480.5, *Safety of Nuclear Facilities,* what specific process is the basis for the identification and control of risks?

ANSWER 1.8-C Safety analysis and review.

EXERCISE 1.8-D Referring to *Fundamentals of Industrial Hygiene* (or any other comparable text), list three disciplines that constitute the typical industrial hygiene/occupational health program.

ANSWER 1.8-D The *occupational physician*, the *occupational nurse*, and the *industrial hygienist*, each supported by ancillary safety and health professionals, including industrial toxicologists and health physicists.

EXERCISE 1.8-E Referring to paragraph 7.a. of DOE 5480.8A, *Contractor Occupational Medical Program,* what is the frequency and the basis that occupational medical physicians must visit each contractor installation?

ANSWER 1.8-E They must make periodic visits based on plant and workforce size; number of different operations; kinds of physical, chemical, or biological agents used; accident and incident rate; occupational illness and disability rate; and occupational medical department staffing level.

EXERCISE 1.8-F Referring to paragraph 7.a. of DOE 5480.8A, *Contractor Occupational Medical Program,* how often are DOE and its contractors required to offer all employees a comprehensive health examination?

ANSWER 1.8-F Annually for employees over age 45, and biennially for all others.

EXERCISE 1.8-G Referring to paragraph 8.k. of DOE 5630.11B, *Safeguards and Security Program*, what action must the head of the field element take if operations would result in unacceptable risk to national security or the health and safety of employees?

ANSWER 1.8-G "Take such action as may be appropriate to ensure acceptable safeguards and security, including curtailment or suspension of operations ..."

EXERCISE 1.8-H Referring to paragraph 9 of DOE 5630.11B, *Safeguards and Security Program*, what are some of the actions that may cause ". . .unacceptable risk to national security or the health and safety of DOE and contractor employees. . .?"

ANSWER 1.8-H Loss or theft of classified matter or government property and acts of unauthorized access, theft, diversion, sabotage, espionage, or other hostile acts.

EXERCISE 1.8-I How do occupational safety personnel get involved in safeguards and security issues?

ANSWER 1.8-I Being responsible for the safety and health of site personnel, they may be able to recognize risks to the health and safety of site personnel; they also may support the safeguards and security staff in defining predetermined risks.

EXERCISE 1.8-J Referring to Attachments 1 and 2 of DOE 5480.4, list at least three of the general categories of mandatory ES&H standards (that encompass DOE and non-DOE federal ES&H statutes and/or requirements).

ANSWER 1.8-J (Any three of the following)

1. Environmental protection
2. Fire protection
3. Occupational health protection
4. Occupational safety
5. Nuclear safety
6. Transportation safety

Competency 1.9 **Occupational safety personnel shall demonstrate a working level knowledge of safety in construction operations.**

1. Supporting Knowledge and Skills

a. Discuss the role of project planning and analysis.

b. Discuss the effect of the transient and dynamic nature of construction activities on the safety program.

c. Discuss safety program considerations on multi-employer construction sites.

d. Discuss the requirements for, the purpose of, and the application of, appropriate preliminary and activity hazard analysis.

e. Demonstrate the ability to:
- Evaluate construction operations and identify construction-related hazards
- Identify, interpret, and apply appropriate construction safety requirements
- Identify and implement appropriate control measures

f. Discuss excavation and trenching hazard and control considerations, including:
- Factors affecting soil stability in a trench
- Application of the different types of shoring, sloping, and shielding systems
- Excavation and trenching inspection considerations

g. Address the following confined space hazard considerations for construction operations:
- Describe the characteristics of a confined space hazard
- Identify potential construction-related confined space locations
- Identify and discuss the application of confined space entry procedures

h. Discuss construction-related electrical considerations (i.e., temporary wiring; grounding; and exposed wires, equipment, or parts).

i. Discuss the following hazards and the use of appropriate controls associated with hoisting and rigging equipment and operations:
- Load test and inspection requirements for cranes
- Effects of boom angle and length on load limits
- Major signs of stress, strain, or other deterioration that must be evaluated when inspecting rigging equipment

- Hazards associated with electrical wires
- Appropriate lifting techniques and limitations, including the relationship between the crane operator and the guide

j. Discuss the following hazard control considerations associated with demolition operations:
   - Structural support considerations
   - Need for project planning and activity hazard analyses
   - Hazards associated with, and the appropriate techniques for removal of debris
   - Hazards associated with remaining energy sources, equipment, and materials (hazardous chemicals/wastes)

k. Identify sources of potential fall hazards and recommend appropriate controls.

l. Discuss construction related heat and cold stress hazards and identify appropriate control measures.

m. Identify general personal protective equipment (PPE) requirements for construction operations.

n. Discuss the hazards and identify appropriate controls associated with construction equipment and operations including, but not limited to:
   - Scaffolding and other elevated work structures or platforms
   - Powder-actuated tools
   - Heavy equipment (i.e., earth moving equipment) and traffic
   - Placement and temporary support of walls, floors, and other structures.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTES:
- The DOE Orders are in a state of transition. Please refer to the following gopher site for a cross reference of new and old Orders: gopher://VM1.HQADMIN.DOE.GOV:70/00/doemenu1/directiv/251cross.asc
- Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Read the Summary section below.

Read DOE Order 5480.9A, *Construction Project Safety and Health Management.*

EXERCISE 1.9-A Discuss the role of project planning and analysis.

EXERCISE 1.9-B Discuss the effect of the transient and dynamic nature of construction activities on the safety program.

EXERCISE 1.9-C Discuss safety program considerations on multi-employer construction sites.

EXERCISE 1.9-D Complete a matrix similar to that shown below, discussing the requirements for, the purpose of, and the application of, appropriate preliminary and activity hazard analysis.

Hazard Analyses Information		
	Preliminary Hazard Analysis	**Activity Hazard Analysis**
Requirement Source		
Purpose		
Application		

Review OSHA 2209, *OSHA Handbook for Small Businesses*.

Review "Safety and Health Regulations for Construction, Subpart K, Electrical," 29 CFR 1926, *Surveillance Guide*, prepared for DOE-ORO.

EXERCISE 1.9-E Work with a subject matter expert at your site to complete the following activities.

- Select an area of a facility or select a construction activity to be assessed. Using a checklist, evaluate construction operations and identify construction-related hazards. One possible source is the Self-Inspection Checklists in OSHA 2209, *OSHA Handbook for Small Businesses*.
- Identify, interpret, and apply appropriate construction safety requirements. One useful reference for this activity is the "Safety and Health Regulations for Construction, Subpart K, Electrical," 29 CFR 1926, *Surveillance Guide*, prepared by DOE-ORO.
- Identify and implement appropriate control measures.

Review 29 CFR 1926, Subpart P, "Excavations."

EXERCISE 1.9-F Discuss excavation and trenching hazard and control considerations including:

- Factors affecting soil stability in a trench
- Application of the different types of shoring, sloping, and shielding systems
- Excavation and trenching inspection considerations

Review DOE-EM-STD-5503-94, *Guidelines For Development of Site-Specific Health and Safety Plans*, published by EM-40.

EXERCISE 1.9-G Address the following confined space hazard considerations for construction operations:

- Describe the characteristics of a confined space hazard
- Identify potential construction related confined space locations
- Identify and discuss the application of confined space entry procedures

Review 29 CFR 1926.403-405.

EXERCISE 1.9-H Using 29 CFR 1926, discuss construction-related electrical considerations, including temporary wiring; grounding; and exposed wires, equipment, or parts.

Review DOE/ID-10500, *Department of Energy Hoisting and Rigging Manual*.

EXERCISE 1.9-I Address the following items associated with hoisting and rigging equipment and operations:

- Load test and inspection requirements for cranes
- Effects of boom angle and length on load limits
- Major signs of stress, strain, or other deterioration that must be evaluated when inspecting rigging equipment
- Hazards associated with electrical wires
- Appropriate lifting techniques and limitations, including the relationship between the crane operator and the guide

Review 29 CFR Part 1926, Subpart T.

EXERCISE 1.9-J Discuss the following hazard control considerations associated with demolition operations:

- Structural support considerations
- Need for project planning and activity hazard analyses
- Hazards associated with and the appropriate techniques for removal of debris
- Hazards associated with remaining energy sources, equipment, and materials (hazardous chemicals/wastes)

Review 29 CFR Part 1926, Subparts C, E, H, L, and M.

EXERCISE 1.9-K Identify potential fall hazards and recommend preventive measures.

Review Chapter 1 of *Fundamentals of Industrial Hygiene*; B.A. Plog, G.S. Benjamin, and M.A. Kerwin; National Safety Council; or another industrial hygiene-related text regarding heat and cold stress.

EXERCISE 1.9-L Construct a matrix similar to the one shown below that describes heat and cold stress hazards and identifies appropriate control measures.

Heat and Cold Stress-Related Hazards		
Type	**Factors**	**Control Measures**
Heat		
Cold		

Review 29 CFR Part 1926, Subpart E.

EXERCISE 1.9-M Using 29 CFR 1926, state the general personal protective equipment (PPE) requirements for construction operations.

EXERCISE 1.9-N Construct a matrix similar to the one shown below that describes the listed hazards and identifies appropriate control measures.

Construction Equipment- and Operations-Related Hazards		
Type	**Description**	**Control Measures**
Scaffolding		
Powder-Actuated Tools		
Heavy Equipment		

3. Summary

Project Planning

As with any project, construction activities are safer and more efficient when an appropriate amount of planning is done. This is particularly important to personnel safety. Construction contractors are required by DOE in order to evaluate the work associated with each project phase and to identify specific hazards to which worksite employees and other worksite personnel may potentially be exposed. This analysis also provides the data needed to identify appropriate control measures.

Dynamic Nature of Construction

Construction activities are safer and more efficient when an appropriate amount of planning is done. The transient and dynamic nature of construction activities makes the need for that planning of paramount importance. It is very easy under construction conditions to make on-the-spot decisions that may advance the construction cause while negating the advantages of safety planning. Therefore, safety issues must be considered any time activities stray from the planned path.

Safety Program Considerations on Multi-Employer Construction Sites

Multi-employer construction sites offer unique problems for safety programs. Each subcontractor firm is responsible for some form of a safety program, as is the primary contracting organization. This situation creates natural problem areas at the responsibility interfaces. The solution to this problem is to identify one person who has total responsibility

for the overall safety program. Another issue that occasionally occurs on multi-employer sites is that existing safety programs within the subcontractor organizations may not be compatible with each other or with the primary contractor's program. These concerns should be resolved in the contract establishment process.

Hazard Analyses

Hazard Analyses Information		
	Preliminary Hazard Analysis	**Activity Hazard Analysis**
Requirements	DOE Order 5480.9A	DOE Order 5480.9A
Purpose	To reduce the likelihood of exposure of worksite employees and other worksite personnel by reviewing the planned work prior to start of the project	To reduce the likelihood of exposure of worksite employees and other worksite personnel during individual phases of construction by reviewing the planned work prior to the start of each phase
Application	• Identify the anticipated construction phases • Identify the types of hazards associated with each anticipated phase of the project • Identify potential control measures and programs necessary to protect employees and others at the worksite • Identify the phases for which requirements for protective measures must exist	• Identify the specific hazards associated with each activity to be performed in that phase of construction • Identify the actual corrective measures planned to control the hazards • Develop drawings and/or other documentation for all protective measures • Designate and identify the qualifications of the person that will conduct inspections where required

Assessing Safety Programs

An assessment or inspection of construction activities can be a useful tool. A subject matter expert at your site should be consulted for review of this area. One reference that provides assistance for the first item is the "Self-Inspection Checklists" in OSHA 2209, *OSHA Handbook for Small Businesses.* A reference that provides assistance for the second and third activities as well as an actual assessment plan is the "Safety and Health Regulations for Construction, Subpart K, Electrical," 29 CFR 1926, *Surveillance Guide,* prepared by DOE-ORO.

Excavation and Trenching Hazards

There are a number of factors that affect soil stability in a trench. Some of the more common factors include the following:

- Nearby traffic
- Nearness of structures
- Condition of nearby structures
- Soil type
- Surface and ground water
- The water table
- Overhead and underground utilities
- Weather

OSHA requires that, in all excavations, employees exposed to potential cave-ins must be protected by sloping or benching the sides of the excavation, supporting the sides of the excavation, or placing a shield between the side of the excavation and the work area. Details regarding sloping and shoring can be found in 29 CFR 1926, Subpart P, "Excavations."

29 CFR 1926, Subpart P requires that a competent person inspect, on a daily basis, excavations and the adjacent areas for possible cave-ins, failures of protective systems and equipment, hazardous atmospheres, or other hazardous conditions. If these conditions are encountered, exposed employees must be removed from the hazardous area until the necessary safety precautions have been taken. Inspections are also required after natural (e.g., heavy rains) or man-made events such as blasting that may increase the potential for hazards.

Confined Space Hazards

A permit-required confined space has one or more of the following characteristics:
- Contains or has a potential to contain a hazardous atmosphere
- Contains a material that has the potential for engulfing an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section
- Contains any other recognized serious safety or health hazard

There are numerous potential construction-related confined space locations. These include, but are not limited to, the following:
- Manholes
- Stacks
- Storage tanks
- Trailers
- Tank cars
- Vats
- Vessels
- Pits
- Sumps
- Hoppers
- Bins
- Trenches
- Rooms
- Tunnels
- Pipes

The following are steps for entry into a confined space. They are generic and, therefore, apply to many confined space entries. However, they may be altered by site or facility procedures.
- Complete the initial portions of a confined space entry permit
- Confirm or perform training to establish personnel proficiency in the duties required
- Test the atmosphere
- Set up atmospheric monitoring to be performed throughout the entry
- If a hazardous atmosphere is detected, evaluate to determine the cause
- Take measures to protect employees before entry is made
- Require proper respiratory equipment if needed
- Complete the confined space entry permit
- Allow entry only after all requirements of the permit are met and it is reviewed and signed

by the entry supervisor or job leader

Construction-Related Electrical Hazards

29 CFR 1926 covers each of the following areas in detail.

- Temporary wiring -- 29 CFR 1926.405 addresses temporary wiring. General requirements exist related to the following:
  - Origination of feeders and branch circuits
  - Location of branch-circuit conductors
  - Types of receptacles
  - Disconnect switches
  - Lamp guards
  - Temporary light suspension
  - Portable electric lighting
  - Cable and raceway systems
  - Protection of flexible cords and cable
  - Extension cords
- Grounding -- 29 CFR 1926.404 covers grounding and includes the following general requirements:
  - Use of ground fault circuit interrupters or an assured equipment grounding conductor program
  - Identification of conductors
  - Polarity of connections
  - Use of grounding terminals and devices
- Exposed wires, equipment, or parts -- 29 CFR 1926.403 covers guarding. General requirements state that guarding shall be provided to prevent access of other than authorized and qualified personnel.

Hoisting and Rigging

The following is a simple list of basic load test and inspection requirements for cranes.

- Prior to initial use, all new, extensively repaired, or altered cranes shall be tested by or under the direction of a qualified inspector. A functional test of the crane under a normal operating load should be made prior to putting the crane back in service.
- Equipment shall be inspected by a competent person before each use and during use, and all deficiencies shall be corrected before further use.
- An annual inspection of the hoisting machinery shall be made by a competent person or by a government or private agency recognized by the U.S. Department of Labor. Records shall be kept of the dates and results of each inspection.

There are several effects that boom angle and length have on load limits.

- A safe load depends upon boom length, boom angle, and working radius.
- Always operate within the rated capacity of the machine.
- Always use the shortest boom possible.
- Never operate the boom at a higher angle than shown on the capacity charts.

Major signs of stress, strain, or other deterioration must be evaluated when inspecting rigging equipment. The following is a partial list of items to be inspected.

- Equipment shall operate with a smooth, regular motion without any hesitation, abnormal vibration, binding, gross shimmy, or irregularity.
- There shall be no apparent damage, excessive wear, or deformation of any part of the equipment.
- All safety devices, load indicators, boom angle and radius indicators, controls, and other operating parts of the equipment shall be checked during each inspection and shall be in good working order.
- Any defects shall be corrected or repaired before the equipment is put into service.
- Parts found to be defective as a result of any inspection or nondestructive examination shall be replaced or repaired as directed by the cognizant line manager or a designated alternate.

Information on the various types of inspections that must be performed on cranes and rigging equipment can be found in DOE/ID-10500, *Department of Energy Hoisting and Rigging Manual*.

There are also possible hazards associated with the use of cranes near electrical wires. Extreme caution must be used when traveling or working a crane near electrical wires. Special procedures are required except where the electrical distribution and transmission lines have been deenergized and are visibly grounded at the point of work.

- If cage-type boom guards, insulating links, or proximity-warning devices are used, they cannot replace having the electrical distribution and transmission lines deenergized and visibly grounded at the point of work.
- Communicate with the owners of the lines prior to commencement of the work and request their cooperation.
- Consider all overhead conductors to be energized unless and until the person owning the conductor or the electric utility verifies that it is not energized.
- Observe the minimum clearance requirements that are based on voltage.
- Observe the signs at the operator's station and on the outside of the crane warning of possible electrocution.

Appropriate lifting techniques and limitations are important in the operation of a crane.

Lifting techniques and limitations can be found in DOE/ID-10500, *Department of Energy Hoisting and Rigging Manual.*

The relationship between the crane operator and the guide is also very important for safe operation.

- All personnel acting as signalers during crane operations shall be clearly identified to the crane operator by the use of one or more of the following: orange hardhat, gloves, and/or vest.
- In those cases where the crane operator cannot see the signaler, a second person (relay signaler) shall be stationed where he/she can see both the signaler and the crane operator and relay signals to the operator.
- Where voice (direct or two-way radio) communication is used, the signaler shall communicate directly with the operator, not through a third person.
- The operator shall recognize signals only from the designated signaler, except that a STOP signal shall be obeyed no matter who gives it.
- The standard signals for DOE use of the particular type of crane or hoist being used shall be as specified in the latest edition of the American National Standards Institute (ANSI) B30 chapters.

Demolition Hazards

There are a number of considerations associated with demolition operations. Some of those are detailed below.

- Structural support considerations
  - Prior to starting all demolition operations, OSHA Standard 1926.850(a) requires that an engineering survey of the structure must be conducted by a competent person. The purpose of this survey is to determine the condition of the framing, floors, and walls so that measures can be taken, if necessary, to prevent the premature collapse of any portion of the structure. When indicated as advisable, any adjacent structure(s) or improvements should also be similarly checked.
  - If the structure to be demolished has been damaged by fire, flood, explosion, or some other cause, appropriate measures, including bracing and shoring of walls and floors, shall be taken to protect workers and any adjacent structures.
- Need for project planning and activity hazard analyses
  - Before the start of every demolition job, the demolition contractor should take a number of steps to safeguard the health and safety of workers at the job site. These preparatory operations involve the overall planning of the demolition job, including the methods to be used to bring the structure down, the equipment necessary to do the job, and the measures to be taken to perform the work safely. Planning for a demolition job is as important as actually doing the work.

- Hazards associated with and the appropriate techniques for removal of debris
  - Various hazards are associated with the removal of debris. Several OSHA requirements that relate to the removal of debris. General precautions include the following:
    - When debris is dropped through holes in the floor without the use of chutes, the area onto which the material is dropped shall be completely enclosed with barricades.
    - Signs to warn of the hazard of falling materials shall be posted at each level. Sign removal shall not be permitted in the lower area until debris handling ceases above.
    - Any chute opening into which workmen dump debris shall be protected by a substantial guardrail.
    - Walls that are to serve as retaining walls against which debris will be piled shall not be so used unless capable of safely supporting the imposed load.
    - Before demolishing any floor arch, debris and other material shall be removed from such arch and other adjacent floor area.
    - Demolition of floor arches shall not be started until the arches have been cleared of debris and any other unnecessary materials.
    - The storage of waste material and debris on any floor shall not exceed the allowable floor loads.
- Hazards associated with remaining energy sources, equipment, and materials (hazardous chemicals/wastes)
  - One of the most important elements of the prejob planning is the location of all utility services. All electric, gas, water, steam, sewer, and other service lines should be shut off, purged (if necessary), capped, or otherwise controlled, at or outside the building before demolition work is started. In each case, any utility company that is involved should be notified in advance, and its approval or services, if necessary, shall be obtained.
  - If it is necessary to maintain power, water, or other utilities during demolition, such lines shall be temporarily relocated as necessary and/or protected. The location of all overhead power sources should also be determined, as they can prove especially hazardous during any machine demolition. All workers should be informed of the location of any existing or relocated utility service.
  - It shall also be determined if any type of hazardous chemicals, gases, explosives, flammable material, or similar dangerous substances have been used or stored on the site. If the nature of a substance cannot be easily determined, samples should be taken and analyzed by a qualified person prior to demolition. The hazardous materials may have to be removed prior to the start of demolition.

Potential Fall Hazards

There are a large number of possible fall hazards. The following table illustrates some examples.

Potential Fall Hazards and Preventive Measures	
Hazard	**Preventive Measure**
Tripping	• Housekeeping • Proper illumination • Guardrails and handrails
Slipping	• Housekeeping • Safety shoes with nonskid soles • Level walking surfaces
Working at Elevations	• Safety lines, harnesses, and lanyards • Ladders and scaffolds inspections • Safety nets
Faulty Ladders, Scaffolds, or Guardrails	• Ladders, scaffolds, and guardrails inspections • Written safety policy to never step on top platform of ladder • Safety cage or rail

Heat Stress or Cold Stress

The construction environment, by its very nature, requires workers to endure extremes of weather and other environmental conditions. Two of these are heat and cold stress. The following table describes each and provides several possible control measures.

Hazards Related to Heat Stress or Cold Stress		
Type	**Factors**	**Control Measures**
Heat	• Common problem • Evaluation of heat stress is not simple • People function efficiently only in a very narrow body temperature range • Protective clothing • Can cause: - Heat stroke - Heat exhaustion - Heat cramps	• Acclimatization periods • Work and rest regimens • Distribution of work load with time • Regular breaks • Provision for water intake • Application of engineering controls
Cold	• Also a common problem • Physical activity increases loss of body heat in a cold environment • Can cause: - Hypothermia - Frostbite	• Work and rest regimens • Distribution of work load with time • Regular breaks • Provision for water intake • Protective clothing • Application of engineering controls

General OSHA Personal Protective Equipment (PPE) Requirements for Construction Operations

- Application -- Protective equipment, including personal protective equipment (PPE) shall be provided, used, and maintained in a sanitary and reliable condition whenever necessary to prevent injury or impairment in the function of any part of the body through absorption, inhalation, or physical contact.
- Employee-owned equipment -- Where employees provide their own protective equipment, the employer shall be responsible to ensure its adequacy, including proper maintenance and sanitation of such equipment.
- Design -- All PPE shall be of safe design and construction in order for the work to be performed.

Construction Equipment- and Operations-Related Hazards

There are a large number of possible items that could be covered under this topic. The following are some examples.

Construction Equipment- and Operations-Related Hazards		
Type	**Hazard Description**	**Control Measures**
Scaffolding	• Falls from scaffolding • Collapse of scaffolding	• Sound footing • Capable of carrying at least four times the maximum intended load • Guardrails and toeboards installed • Planking is scaffold grade or equivalent
Powder-Actuated Tools	• Accidental firing causing injury • Powder burns • Misfire • Flying dirt, scale, etc. • Ignition of explosive or combustible atmosphere	• Only trained employees shall be allowed to operate powder-actuated tools • All powder-actuated tools shall be tested daily before use and all defects discovered before or during use shall be corrected • Tools shall not be loaded until immediately before use. Loaded tools shall not be left unattended • Eye/face protection • Hearing protection
Heavy Equipment	• Hearing damage • Injury from being struck by vehicle • Injury from flying objects • Operating accidents • Combustion by-products	• Wear hearing protection • Maintain awareness of equipment • Avoid heavy traffic areas • Post warning signs • Wear hard hats • Ensure adequate ventilation • Ensure adequate guarding • Frequent equipment inspections • Proper equipment maintenance • Audible reverse warning

4. Exercise Solutions

EXERCISE 1.9-A Discuss the role of project planning and analysis.

ANSWER 1.9-A As with any project, construction activities are safer and more efficient when an appropriate amount of planning is done. This is particularly important to personnel safety. Construction contractors are required by DOE to evaluate the work associated with each project phase and to identify specific hazards to which worksite employees and other worksite personnel may potentially be exposed. This analysis also provides the data needed to identify appropriate control measures.

EXERCISE 1.9-B Discuss the effect of the transient and dynamic nature of construction activities on the safety program.

ANSWER 1.9-B Construction activities are safer and more efficient when an appropriate amount of planning is done. The transient and dynamic nature of construction activities makes the need for that planning of paramount importance. It is very easy under construction conditions to make on-the-spot decisions that may advance the construction cause while negating the advantages of safety planning. Therefore, safety issues must be considered any time activities stray from the planned path.

EXERCISE 1.9-C Discuss safety program considerations on multi-employer construction sites.

ANSWER 1.9-C Multi-Employer construction sites offer unique problems for safety programs. Each subcontractor firm is responsible for some form of a safety program, as is the primary contracting organization. This situation creates natural problem areas at the responsibility interfaces. The solution to this problem is to identify one person who has total responsibility for the overall safety program. Another issue that occasionally occurs on multi-employer sites is that existing safety programs within the subcontractor organizations may not be compatible with each other or with the primary contractor's program. These concerns should be resolved in the contract establishment process.

EXERCISE 1.9-D Complete a matrix similar to that shown in Exercise 1.9-D in Section 2, Self-Study Activities, discussing the requirements for, the purpose of, and the application of appropriate preliminary and activity hazard analysis.

ANSWER 1.9-D

Hazard Analyses Information		
	Preliminary Hazard Analysis	**Activity Hazard Analysis**
Requirements	DOE Order 5480.9A	DOE Order 5480.9A
Purpose	To reduce the likelihood of exposure of worksite employees and other worksite personnel by reviewing the planned work prior to start of the project	To reduce the likelihood of exposure of worksite employees and other worksite personnel during individual phases of construction by reviewing the planned work prior to the start of each phase
Application	• Identify the anticipated construction phases • Identify the types of hazards associated with each anticipated phase of the project • Identify potential control measures and programs necessary to protect employees and others at the worksite • Identify the phases for which requirements for protective measures must exist	• Identify the specific hazards associated with each activity to be performed in that phase of construction • Identify the actual corrective measures planned to control the hazards • Develop drawings and/or other documentation for all protective measures • Designate and identify the qualifications of the person that will conduct inspections where required

EXERCISE 1.9-E

Work with a subject matter expert at your site to complete the following activities.

- Select an area of a facility or select a construction activity to be assessed. Using a checklist, evaluate construction operations and identify construction-related hazards. One possible source is the Self-Inspection Checklists in OSHA 2209, *OSHA Handbook for Small Businesses*.
- Identify, interpret, and apply appropriate construction safety requirements. One useful reference for this activity is the "Safety and Health Regulations for Construction, Subpart K, Electrical," 29 CFR 1926, *Surveillance Guide*, prepared for DOE-ORO.
- Identify and implement appropriate control measures

ANSWER 1.9-E

An assessment or inspection of construction activities can be a useful tool. It is beyond the scope of this self study guide to cover this item in detail. A subject matter expert at your site should be consulted for review of this item. One reference that provides assistance for the first item is the Self-Inspection Checklists in OSHA 2209, *OSHA Handbook for Small Businesses*. A reference that provides assistance for the second and third activities as well as an actual assessment plan is the "Safety and Health Regulations for Construction, Subpart K, Electrical," 29 CFR 1926, *Surveillance Guide*, prepared by DOE-ORO.

EXERCISE 1.9-F

Discuss excavation and trenching hazard and control considerations including:

- Factors affecting soil stability in a trench
- Application of the different types of shoring, sloping, and shielding systems
- Excavation and trenching inspection considerations

ANSWER 1.9-F

- There are a number of factors that affect soil stability in a trench. Some of the more common factors include the following:
  - Nearby traffic
  - Nearness of structures
  - Condition of nearby structures
  - Soil type
  - Surface and ground water
  - The water table

  - Overhead and underground utilities
  - Weather
- OSHA requires that, in all excavations, employees exposed to potential cave-ins must be protected by sloping or benching the sides of the excavation, supporting the sides of the excavation, or placing a shield between the side of the excavation and the work area. Details regarding sloping and shoring can be found in 29 CFR 1926, Subpart P, "Excavation."
- 29 CFR 1926, Subpart P requires that a competent person inspect, on a daily basis, excavations and the adjacent areas for possible cave-ins, failures of protective systems and equipment, hazardous atmospheres, or other hazardous conditions. If these conditions are encountered, exposed employees must be removed from the hazardous area until the necessary safety precautions have been taken. Inspections are also required after natural (e.g., heavy rains) or man-made events, such as blasting, that may increase the potential for hazards.

EXERCISE 1.9-G Address the following confined space hazard considerations for construction operations:

- Describe the characteristics of a confined space hazard
- Identify potential construction-related confined space locations
- Identify and discuss the application of confined space entry procedures

ANSWER 1.9-G

- A permit-required confined space has one or more of the following characteristics:
  - Contains or has a potential to contain a hazardous atmosphere
  - Contains a material that has the potential for engulfing an entrant
  - Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section
  - Contains any other recognized serious safety or health hazard
- There are numerous possible answers to this question. These include, but are not limited to, the following:
  - Manholes
  - Stacks
  - Storage tanks
  - Trailers

  - Tank cars
  - Vats
  - Vessels
  - Pits
  - Sumps
  - Hoppers
  - Bins
  - Trenches
  - Rooms
  - Tunnels
  - Pipes
- The following steps for entry into a confined space are generic and, therefore, apply to many confined space entries. However, these steps may be altered by site or facility procedures.
  - Complete the initial portion of a confined space entry permit
  - Confirm or perform training to establish personnel proficiency in the duties required
  - Test the atmosphere (O_2, explosive limits, toxic atmosphere) as required
  - Set up atmospheric monitoring to be performed throughout the entry
  - If a hazardous atmosphere is detected, evaluate to determine the cause
  - Take measures to protect employees before entry is made
  - Require proper respiratory equipment if needed
  - Complete the confined space entry permit
  - Allow entry only after all requirements of the permit are met and it is reviewed and signed by the entry supervisor or job leader.

EXERCISE 1.9-H Using 29 CFR 1926, discuss construction-related electrical considerations, including temporary wiring; grounding; and exposed wires, equipment, or parts.

ANSWER 1.9-H 29 CFR 1926 covers each of the following areas in detail.

- Temporary wiring -- 29 CFR 1926.405 covers temporary wiring. General requirements exist related to the following:
  - Origination of feeders and branch circuits
  - Location of branch-circuit conductors
  - Types of receptacles

  - Disconnect switches
  - Lamp guards
  - Temporary light suspension
  - Portable electric lighting
  - Cable and raceway systems
  - Protection of flexible cords and cable
  - Extension cords
- Grounding -- 29 CFR 1926.404 covers grounding and includes the following general requirements:
  - Use of ground fault circuit interrupters or an assured equipment grounding conductor program
  - Identification of conductors
  - Polarity of connections
  - Use of grounding terminals and devices
- Exposed wires, equipment, or parts -- 29 CFR 1926.403 covers guarding. General requirements exist that state that guarding shall be provided to prevent access of other than authorized and qualified personnel.

EXERCISE 1.9-I Address the following items associated with hoisting and rigging equipment and operations:

- Load test and inspection requirements for cranes
- Effects of boom angle and length on load limits
- Major signs of stress, strain, or other deterioration that must be evaluated when inspecting rigging equipment
- Hazards associated with electrical wires
- Appropriate lifting techniques and limitations including the relationship between the crane operator and the guide

ANSWER 1.9-I

- Load test and inspection requirements for cranes
  - Prior to initial use, all new, extensively repaired, or altered cranes shall be tested by or under the direction of a qualified inspector. A functional test of the crane under a normal operating load should be made prior to putting the crane back in service.
  - Equipment shall be inspected by a competent person before each use and during use, and all deficiencies shall be corrected before further use.
  - An annual inspection of the hoisting machinery shall be made by

a competent person or by a government or private agency recognized by the U.S. Department of Labor. Records shall be kept of the dates and results of each inspection.

- Effects of boom angle and length on load limits
  - A safe load depends upon boom length, boom angle, and working radius.
  - Always operate within the rated capacity of the machine.
  - Always use the shortest boom possible.
  - Never operate the boom at a higher angle than shown on the capacity charts.
- Major signs of stress, strain, or other deterioration that must be evaluated when inspecting rigging equipment
  - Equipment shall operate with a smooth, regular motion without any hesitation, abnormal vibration, binding, gross shimmy, or irregularity.
  - There shall be no apparent damage, excessive wear, or deformation of any part of the equipment.
  - All safety devices, load indicators, boom angle and radius indicators, controls, and other operating parts of the equipment shall be checked during each inspection and shall be in good working order.
  - Any defects shall be corrected or repaired before the equipment is put into service.
  - Parts found to be defective as a result of any inspection or nondestructive examination shall be replaced or repaired as directed by the cognizant line manager or a designated alternate.

Information on the various types of inspections that must be performed on cranes and rigging equipment can be found in DOE/ID-10500, *Department of Energy Hoisting and Rigging Manual*.

- Hazards associated with electrical wires
  - Extreme caution must be used when traveling or working a crane near electrical wires. Special procedures are required except where the electrical distribution and transmission lines have been deenergized and are visibly grounded at the point of work.
    - If cage-type boom guards, insulating links, or proximity-warning devices are used, they cannot replace having the electrical distribution and transmission lines deenergized and

visibly grounded at the point of work.

- Communicate with the owners of the lines prior to commencement of the work and request their cooperation.

- Consider all overhead conductors to be energized unless and until the person owning the conductor or the electric utility verifies that it is not energized.
- Observe the minimum clearance requirements that are based on voltage.
- Observe the signs at the operator's station and on the outside of the crane warning of possible electrocution.

- Appropriate lifting techniques and limitations including the relationship between the crane operator and the guide
  - The relationship between the crane operator and the guide is very important for safe operation.
    - All personnel acting as signalers during crane operations shall be clearly identified to the crane operator by the use of one or more of orange hardhat, gloves, and/or vest.
    - In those cases where the crane operator cannot see the signaler, a second person (relay signaler) shall be stationed where he/she can see both the signaler and the crane operator and relay signals to the operator.
    - Where voice (direct or two-way radio) communication is used, the signaler shall communicate directly with the operator not through a third person.
    - The operator shall recognize signals only from the designated signaler, except that a STOP signal shall be obeyed no matter who gives it.
    - The standard signals for DOE use shall be as specified in the latest edition of the American National Standards Institute (ANSI) B30 chapters, for the particular type of crane or hoist being used.

  Lifting techniques and limitations can be found in DOE/ID-10500, *Department of Energy Hoisting and Rigging Manual*.

EXERCISE 1.9-J Discuss the following hazard control considerations associated with demolition operations:

- Structural support considerations
- Need for project planning and activity hazard analyses
- Hazards associated with and the appropriate techniques for removal of debris
- Hazards associated with remaining energy sources, equipment, and materials (hazardous chemicals/wastes)

ANSWER 1.9-J

- Structural support considerations
  - Prior to starting all demolition operations, OSHA Standard 1926.850(a) requires that an engineering survey of the structure must be conducted by a competent person. The purpose of this survey is to determine the condition of the framing, floors, and walls so that measures can be taken, if necessary, to prevent the premature collapse of any portion of the structure. When indicated as advisable, any adjacent structure(s) or improvements should also be similarly checked.
  - If the structure to be demolished has been damaged by fire, flood, explosion, or some other cause, appropriate measures, including bracing and shoring of walls and floors, shall be taken to protect workers and any adjacent structures.
- Need for project planning and activity hazard analyses
  - Before the start of every demolition job, the demolition contractor should take a number of steps to safeguard the health and safety of workers at the job site. These preparatory operations involve the overall planning of the demolition job, including the methods to be used to bring the structure down, the equipment necessary to do the job, and the measures to be taken to perform the work safely. Planning for a demolition job is as important as actually doing the work.
- Hazards associated with and the appropriate techniques for removal of debris
  - Various hazards are associated with the removal of debris. Several OSHA requirements exist that relate to the removal of debris. General precautions include the following:
    - When debris is dropped through holes in the floor without the use of chutes, the area onto which the material is dropped shall be completely enclosed with barricades.

- Signs warning of the hazard of falling materials shall be posted at each level. Removal shall not be permitted in this lower area until debris handling ceases above.
- Any chute opening, into which workmen dump debris, shall be protected by a substantial guardrail.
- Walls, which are to serve as retaining walls against which debris will be piled, shall not be so used unless capable of safely supporting the imposed load.
- Before demolishing any floor arch, debris and other material shall be removed from such arch and other adjacent floor area.
- Demolition of floor arches shall not be started until they have been cleared of debris and any other unnecessary materials.
- The storage of waste material and debris on any floor shall not exceed the allowable floor loads.

- Hazards associated with remaining energy sources, equipment, and materials (hazardous chemicals/wastes)
  - One of the most important elements of the prejob planning is the location of all utility services. All electric, gas, water, steam, sewer, and other service lines should be shut off, capped, or otherwise controlled at or outside the building before demolition work is started. In each case, any utility company that is involved shall be notified in advance, and its approval or services, if necessary, should be obtained.
  - If it is necessary to maintain any power, water, or other utilities during demolition, such lines shall be temporarily relocated as necessary and/or protected. The location of all overhead power sources should also be determined, as they can prove especially hazardous during any machine demolition. All workers should be informed of the location of any existing or relocated utility service.
  - It shall also be determined if any type of hazardous chemicals, gases, explosives, flammable material, or similar dangerous substances have been used or stored on the site. If the nature of a substance cannot be easily determined, samples should be taken and analyzed by a qualified person prior to demolition.

EXERCISE 1.9-K Identify potential fall hazards and recommend preventive measures.

ANSWER 1.9-K There are a large number of possible correct answers to this exercise. The following table shows some, but not all, of those possible answers.

Potential Fall Hazards and Preventive Measures	
Hazard	**Preventive Measure**
Tripping	• Housekeeping • Proper illumination • Guardrails and handrails
Slipping	• Housekeeping • Safety shoes with nonskid soles • Level walking surfaces
Working At Elevations	• Safety lines, harnesses, and lanyards • Ladders and scaffolds inspections • Safety nets
Faulty Ladders, Scaffolds, or Guardrails	• Ladders, scaffolds, and guardrails inspection • Written safety policy to never step on top platform of ladder • Safety cage or rail

EXERCISE 1.9-L Construct a matrix similar to the one shown in Exercise 1.9-L that describes heat and cold stress hazards and identifies appropriate control measures.

ANSWER 1.9-L The construction environment, by its very nature, requires workers to endure the extremes of weather and other environmental conditions. Two of these are heat and cold stress. The following table describes each and provides several possible control measures.

Heat- and Cold-Stress Related Hazards		
Type	**Factors**	**Control Measures**
Heat	• Common problem • Evaluation of heat stress is not simple • People function efficiently only in a very narrow body temperature range • Protective clothing • Can cause: - Heat stroke - Heat exhaustion - Heat cramps	• Acclimatization periods • Work and rest regimens • Distribution of work load with time • Regular breaks • Provision for water intake • Application of engineering controls
Cold	• Also a common problem • Physical activity increases loss of body heat in a cold environment • Can cause: - Hypothermia - Frostbite	• Work and rest regimens • Distribution of work load with time • Regular breaks • Provision for water intake • Protective clothing • Application of engineering controls

EXERCISE 1.9-M Using 29 CFR 1926, state the general personal protective equipment (PPE) requirements for construction operations.

ANSWER 1.9-M
- Application -- Protective equipment, including PPE shall be provided, used, and maintained in a sanitary and reliable condition whenever it is necessary in the function of any part of the body through absorption, inhalation, or physical contact.
- Employee-owned equipment -- Where employees provide their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.
- Design -- All PPE shall be of safe design and construction for the work to be performed.

EXERCISE 1.9-N Construct a matrix similar to the one shown in Exercise 1.9-N that describes the listed hazards and identifies appropriate control measures.

ANSWER 1.9-N There are a large number of possible correct answers to this exercise. The following table shows some, but not all, of those possible answers.

Construction Equipment- and Operations-Related Hazards		
Type	**Description**	**Control Measures**
Scaffolding	• Falls from scaffolding • Collapse of scaffolding	• Sound footing • Capable of carrying at least four times the maximum intended load • Guardrails and toeboards installed • Planking is scaffold grade or equivalent
Powder Actuated Tools	• Accidental firing causing injury • Powder burns • Misfire • Flying dirt, scale, etc. • Ignition of explosive or combustible atmosphere	• Only trained employees shall be allowed to operate powder-actuated tools • All powder-actuated tools shall be tested daily before use and all defects discovered before or during use shall be corrected • Tools shall not be loaded until immediately before use. Loaded tools shall not be left unattended • Eye/face protection • Hearing protection
Heavy Equipment	• Hearing damage • Injury from being struck by vehicle • Injury from flying objects • Operating accidents • Combustion by-products	• Wear hearing protection • Maintain awareness of equipment • Avoid heavy traffic areas • Post warning signs • Wear hard hats • Ensure adequate ventilation • Ensure adequate guarding • Frequent equipment inspections • Proper equipment maintenance

Competency 1.10 **Occupational safety personnel shall demonstrate a working level knowledge of the application of hazard control methods.**

1. Supporting Knowledge and Skills

a. Discuss the preferred hierarchy of hazard control methods.

b. Identify common types of engineering and administrative controls and discuss the applicability of each.

c. Discuss the appropriate actions to take in response to the report or discovery of an imminent danger situation.

d. Discuss the elements and appropriate application of a hazard abatement program.

e. Analyze a given identified hazard and recommend acceptable control measures.

f. Identify the circumstances that warrant the use of personal protective equipment (PPE) as a hazard control method.

g. Describe the various types and intended functions of personal protective equipment (PPE).

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Read 29 CFR 1910.119, Appendix C, Compliance Guidelines and Recommendations for Process Safety Management; and the introductory chapters of *Fundamentals of Industrial Hygiene* (or a comparable fundamentals of industrial hygiene text.)

EXERCISE 1.10-A What are three primary categories of hazard control measures or methods? Provide examples.

EXERCISE 1.10-B What is the preferred hierarchy of implementation of the hazard controls and why?

Read 29 CFR 1910.120 (g), "Engineering controls, work practices, and personal protective equipment for employee protection."

EXERCISE 1.10-C Referring to 29 CFR 1910.120 (g), under what general circumstances would the personal protective equipment (PPE) be used as a control measure to reduce and maintain to or below the permissible exposure limits or dose limits?

Read Chapter 12 of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities,* and **scan** 29 CFR 1910.120 (q).

EXERCISE 1.10-D What are the immediate actions one should take upon discovery of an unknown hazardous material spill?

Read Chapters 9 and 10 of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.*

EXERCISE 1.10-E Referring to Chapter 9 of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, what are the three purposes of site control?

EXERCISE 1.10-F Referring to Chapter 9 of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, what are the seven basic components of site control?

EXERCISE 1.10-G Describe how the buddy system is used when performing activities involving hazardous materials.

Read paragraphs (a) through (e) of 29 CFR 1910.119, Process safety management of highly hazardous chemicals.

EXERCISE 1.10-H Referring to paragraph (e) of 29 CFR 1910.119, what are the major steps of a process hazard analysis?

EXERCISE 1.10-I How are operating procedures related to hazardous material controls?

Read the DOE Interim Guidance for Emergency Medical Support in U.S. Department of Energy, Office of Emergency Planning and Operations, *Emergency Management Guide*.

EXERCISE 1.10-J Referring to DOE Interim Guidance for Emergency Medical Support in U.S. Department of Energy, name at least three types of facilities, equipment, and supplies that should be maintained at onsite medical decontamination and treatment centers.

Read Chapter 8, "Personal Protective Equipment (PPE)," of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*; **scan** Subpart I, "Personal Protective Equipment," of 29 CFR 1910, *Occupational Safety and Health Standards for General Industry*; and **read** 29 CFR 1910.120 (g), "Engineering controls, work practices, and personal protective equipment for employee protection," Appendix B, "General Description and Discussion of the Levels of Protection and Protective Gear."

EXERCISE 1.10-K What are the two basic objectives of any personal protective equipment (PPE) program?

EXERCISE 1.10-L Referring to paragraph (a) of Subpart I, 29 CFR 1910.132, when shall personal protective equipment be provided and used?

EXERCISE 1.10-M Referring to Chapter 8, Personal Protective Equipment (PPE), of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, what are the primary and secondary considerations when selecting protective clothing?

EXERCISE 1.10-N Referring to Subpart I, 29 CFR 1910.132 and to Appendix B of 29 CFR 1910.120, what are the areas of the human body that are afforded protection by personal protective equipment (PPE)?

EXERCISE 1.10-O Referring to Chapter 8, "Personal Protective Equipment (PPE)," of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities,* complete the intended purpose of the listed types of personal protective equipment (PPE) in the following table.

Types and Purpose of Personal Protective Equipment (PPE)		
Body Part Protected	**PPE**	**Purpose**
Eyes and face	Face shield	
	Splash hood	
	Safety glasses	
	Goggles	
	Sweat bands	
Respiratory	Self-contained breathing apparatus	
	Supplied-air respirators	
	Air-purifying respirators	
Hands and arms	Gloves and sleeves	
Feet	Safety boots	
	Disposable shoe or boot covers	
Head	Safety helmet	
	Hood	
	Protective hair covering	

Types and Purpose of Personal Protective Equipment (PPE)		
Body Part Protected	**PPE**	**Purpose**
Full body	Fully encapsulating suit	
	Nonencapsulating suit	
	Aprons, leggings, and sleeve protectors	

3. Summary

The control of occupational health hazards requires that an employee's exposure to harmful chemical agents, physical stresses, and physical agents does not exceed permissible levels. The variables or quantities of interest that must be measured are the concentration or intensity of the particular hazard and the duration of exposure.

The types of hazard control measures to be installed depend on the nature of the harmful substance or agent and its routes of entry or absorption into the body. An employee's exposure to an airborne substance is related to the amount of contaminants in the breathing zone and the time interval during which an employee is exposed to this concentration. Reducing the amount of contaminant in the employee's breathing zone or the amount of time that an employee spends in the area will reduce the overall exposure.

Various methods of control available to industrial hygienists are broken down into these categories:

- Engineering controls that eliminate the hazard, either by initial design specifications or by applying methods of substitution, isolation, or ventilation.
- Administrative controls that restrict employees' exposures by scheduling reduced work times in contaminated areas, and by other work rules.
- PPE that should be considered a method of last resort when engineering controls are not sufficient to achieve acceptable limits of exposure. PPE can be used in conjunction with engineering and administrative controls, and with other methods.

The specific application of these controls, used according to the hazard involved, is dictated by such regulations as 29 CFR 1910 and 29 CFR 1926.

4. Exercise Solutions

EXERCISE 1.10-A What are three primary categories of hazard control measures or methods? Provide examples.

ANSWER 1.10-A
- Engineering - built-in or designed-in protection, application of substitution, isolation, or ventilation methods
- Administrative - scheduled reduced work times, moving the work area, housekeeping, maintenance, or employee information and training
- Personal protective equipment - respirators, safety glasses and shields, gloves, aprons, and bubble suits

EXERCISE 1.10-B What is the preferred hierarchy of implementation of the hazard controls and why?

ANSWER 1.10-B Engineering controls first, then administrative, with personal protective equipment as the last choice; this approach minimizes human intervention with the hazard.

EXERCISE 1.10-C Referring to 29 CFR 1910.120 (g), under what general circumstances would the personal protective equipment (PPE) be used as a control measure to reduce and maintain to or below the permissible exposure limits or dose limits?

ANSWER 1.10-C Whenever emergency controls and work practices are not feasible or not required.

EXERCISE 1.10-D What are the immediate actions one should take upon discovery of an unknown hazardous material spill?

ANSWER 1.10-D
1. Notify personnel working in the area.
2. Stop work activities.
3. Evacuate personnel as necessary and keep people out of the affected area until assistance or emergency responders arrive.

EXERCISE 1.10-E Referring to Chapter 9 of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, what are the three purposes of site control?

ANSWER 1.10-E
1. To minimize potential contamination of workers.
2. To protect the public from the site's hazards.
3. To prevent vandalism.

EXERCISE 1.10-F Referring to Chapter 9 of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, what are the seven basic components of site control?

ANSWER 1.10-F
1. Site map
2. Site preparation
3. Site work zones
4. The buddy system
5. Site security
6. Communication systems
7. Safe work practices

EXERCISE 1.10-G Describe how the buddy system is used when performing activities involving hazardous materials.

ANSWER 1.10-G Most activities in contaminated or otherwise hazardous areas should be conducted with a buddy who is able to:
- Provide the partner with assistance.
- Observe the partner for signs of chemical or heat exposure.
- Periodically check the integrity of the partner's protective clothing.
- Notify the command post supervisor (or incident commander) or others if emergency help is needed.

EXERCISE 1.10-H Referring to paragraph (e) of 29 CFR 1910.119, what are the major steps of a process hazard analysis?

ANSWER 1.10-H
1. Determine and evaluate the hazards of the process in question, using established methodologies such as what if, failure mode and effects analysis, and fault tree analysis.
2. Identify any previous incident, that had a likely potential for catastrophic consequences in the workplace.
3. Determine the engineering and administrative controls applicable to the hazards, and their interrelationships.
4. Identify the consequences of failure of the controls.
5. Conduct a facility siting.
6. Assess and determine the human factors requirements.
7. Conduct a qualitative evaluation of the range of possible safety and health effects of failure of controls on employees in the workplace.

EXERCISE 1.10-I How are operating procedures related to hazardous material controls?

ANSWER 1.10-I Operating procedures are part of process safety management, and as such are a tool to provide structure and repeatability while ensuring safe operations. The operating procedures encompass and incorporate safe work practices, which are controls to maintain a safety awareness and to enforce safety rules.

EXERCISE 1.10-J Referring to DOE Interim Guidance for Emergency Medical Support in U.S. Department of Energy, name at least three types of facilities, equipment, and supplies that should be maintained at onsite medical decontamination and treatment centers.

ANSWER 1.10-J (Any three of the following:)
1. Designated contaminated personnel entrance
2. Contamination removal area
3. Showers with used water collection ability
4. Radiation survey instruments and decontamination supplies
5. Separate showers and change rooms for medical and HP personnel
6. Chelation therapy treatment capability
7. Chemical burn treatments and antidotes

EXERCISE 1.10-K What are the two basic objectives of any personal protective equipment (PPE) program?

ANSWER 1.10-K
1. To protect the wearer from safety and health hazards.
2. To prevent injury to the wearer from incorrect use and/or malfunction.

EXERCISE 1.10-L Referring to paragraph (a) of Subpart I, 29 CFR 1910.132, when shall personal protective equipment be provided and used?

ANSWER 1.10-L (Any reasonable paraphrase of the following:) "Whenever it is necessary by reason of hazards of processes or environment, chemical hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation, or physical contact."

EXERCISE 1.10-M Referring to Chapter 8, "Personal Protective Equipment (PPE)," of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, what are the primary and secondary considerations when selecting protective clothing?

ANSWER 1.10-M Primary:
- permeation
- degradation
- penetration
- heat transfer

Secondary:
- durability
- flexibility
- temperature effects
- ease of decontamination
- compatibility with other personal protective equipment
- duration of use

EXERCISE 1.10-N Referring to Subpart I, 29 CFR 1910.132 and to Appendix B of 29 CFR 1910.120, what are the areas of the human body that are afforded

protection by personal protective equipment (PPE)?

ANSWER 1.10-N

- Full body
- Head
- Eyes and face
- Ears
- Hands and arms
- Feet

EXERCISE 1.10-O Referring to Chapter 8, "Personal Protective Equipment (PPE)," of NIOSH/OSHA/USCG/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities,* in the following table complete the intended purpose of the listed types of personal protective equipment (PPE) in the following table.

ANSWER 1.10-O

Types and Purpose of Personal Protective Equipment (PPE)		
Body Part Protected	**PPE**	**Purpose**
Eyes and face	Face shield	Protects against chemical splashes.
	Splash hood	Protects against chemical splashes.
	Safety glasses	Protect eyes against large particles and projectiles.
	Goggles	Can protect against vaporized chemicals, splashes, large particles, and projectiles.
	Sweat bands	Prevent sweat-induced eye irritation and vision impairment.
Respiratory	Self-contained breathing apparatus	Provides the highest available level of protection against airborne contaminants and oxygen deficiency.
	Supplied-air respirators	Protect against most airborne contaminants and permitted for use in oxygen-deficient atmospheres.
	Air-purifying respirators	Protect against specific chemicals and particulates up to specific concentrations.

Types and Purpose of Personal Protective Equipment (PPE)		
Body Part Protected	**PPE**	**Purpose**
Hands and arms	Gloves and sleeves	Protect hands and arms from chemical contact.
Feet	Safety boots	Protect feet from contact with chemicals and from compression, crushing, or puncture by falling, moving, or sharp objects.
	Disposable shoe or boot covers	Protect safety shoes or boots from contamination.
Head	Safety helmet	Protects head from blows.
	Hood	Protects against chemical splashes, particulates, and rain.
	Protective hair covering	Protects hair against chemical contamination, entanglement in machinery or equipment, or from interfering with vision and with the functioning of respiratory devices.
Full body	Fully encapsulating suit	Protects against splashes, dust, gases, and vapors.
	Nonencapsulating suit	Protects against splashes, dust, and other materials, but not against gases and vapors.
	Aprons, leggings, and sleeve protectors	Provide additional splash protection of chest, forearms, and legs.

Competency 1.11 **Occupational safety personnel shall demonstrate familiarity with the application of basic and applied sciences to safety considerations.**

1. Supporting Knowledge and Skills

a. Discuss the role of mathematical tools (including algebra, trigonometry, calculus, statistics, and symbolic logic) in the safety field in analyzing quantities, magnitudes, an forms and their relationships and attributes.

b. Discuss the laws of physics associated with mechanics, heat, light, sound, electricity, magnetism, and radiation and the application of these laws in the safety field.

c. Discuss basic chemistry concepts including atomic structure, bonding, states of matter, chemical energetics and equilibrium, and chemical kinetics.

d. Discuss the biological sciences including heredity, diversity, reproduction, development, structure, and function of the cells, organisms, and populations, with emphasis on human biology.

e. Discuss behavioral sciences including such considerations as individual differences, attitudes, learning, perception, and group behavior and the application of these considerations to the safety field.

f. Discuss the general engineering and technology disciplines including applied mechanics, properties of materials, electrical circuits and machines, principles of engineering design and drawings, and computer science.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Due to the scope of the subject matter, a review of the listed material is suggested. If the candidate needs more in-depth study, the handbook series each contain several exercises in particular subject areas.

Review DOE-HDBK-1014-92, *Fundamentals Handbook*, "Mathematics," Volumes 1 and 2.

Review DOE-HDBK-110-92, *Fundamentals Handbook*, "Classical Physics."

Review DOE-HDBK-1015-93, *Fundamentals Handbook*, "Chemistry," Volumes 1 and 2.

Review *Fundamentals of Industrial Hygiene*, 3rd Edition, National Safety Council, 1988 (Parts 1 & 2).

Review *Industrial Toxicology, Safety, and Health Applications in the Workplace*, edited by Phillip L. Williams and James L. Burson, Van Nostrand Reinhold, New York, 1985.

Review DOE *Guide to Good Practices for Teamwork Training and Diagnostic Skills Development*.

Review DOE-HDBK-1016-93, *Fundamentals Handbook*, "Engineering Symbology," Prints, and Drawings.

Review DOE-HDBK-1017-93, *Fundamentals Handbook*, "Material Science," Volumes 1 & 2.

Review DOE-HDBK-1018-93, *Fundamentals Handbook*, "Mechanical Science," Volumes 1 & 2.

Review DOE-HDBK-1012-93, *Fundamentals Handbook*, "Thermodynamics, Heat Transfer, and Fluid Flow," Volumes 1-3.

Review DOE-HDBK-1011-93, *Fundamentals Handbook*, "Electrical Science," Volumes 1-4.

3. Summary

None.

4. Exercise Solutions

See the above listed handbooks.

Competency 1.12 **Occupational safety personnel shall demonstrate a working level knowledge of safety considerations associated with industrial operations.**

1. Supporting Knowledge and Skills

a. Discuss common industrial and maintenance operations (i.e., welding, material handling, machining, cleaning, coating, etc.) and the safety interfaces necessary to protect workers.

b. Describe the safety considerations associated with the placement of operations and equipment (i.e., location of personnel in the proximity of moving equipment or parts, traffic patterns, structural support for equipment, etc.).

c. Discuss point of operation hazards associated with workplace equipment and describe principles of appropriate machine guarding.

d. Discuss common concerns and associated control measures which must be addressed in the workplace environment (e.g., noise, thermal burn hazards, heat stress, vibration, eye hazards, workplace illumination, etc.).

e. Discuss the hazards associated with non-ionizing radiation and describe the appropriate control measures.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Read the Summary section below.

Review 29 CFR 1910, *Occupational Safety and Health Standards for General Industry*.

EXERCISE 1.12-A Identify at least three general safety interfaces used to protect workers from each of the following common industrial and maintenance operations:

- Welding
- Material handling
- Machining
- Cleaning
- Coating

EXERCISE 1.12-B Describe the safety considerations associated with the placement of operations and equipment.

Review 29 CFR Part 1910, Subpart O.

EXERCISE 1.12-C What are "point of operation" hazards?

EXERCISE 1.12-D Using 29 CFR Part 1910, Subpart O, define "guard," as used in machinery, and state the primary general requirement for machine guards.

EXERCISE 1.12-E Using 29 CFR Part 1910, develop a matrix similar to the one shown below. Use the matrix to identify control measures related to the following workplace environmental hazards:

- Noise
- Thermal burns
- Heat stress
- Eye hazards
- Workplace illumination

Workplace Environmental Hazards and Control Measures	
Hazard	**Control Measures**
Noise	
Thermal Burns	
Heat Stress	
Eye Hazards	
Illumination	

Review Chapter 11 of *Fundamentals of Industrial Hygiene*, National Safety Council, or another industrial hygiene-related text that includes content regarding non-ionizing radiation.

EXERCISE 1.12-F Using Chapter 11 of *Fundamentals of Industrial Hygiene*, National Safety Council, or another industrial hygiene-related text that includes content regarding non-ionizing radiation, develop a matrix similar to the one shown below. Use the matrix to identify possible effects and control measures related to the following non-ionizing radiation hazards:

- Ultraviolet radiation
- Visible energy
- Infrared radiation
- Microwaves and radio waves
- Power transmission
- Radar
- Lasers

Non-Ionizing Radiation Hazards and Control Measures		
Radiation Form	**Possible Effects**	**Control Measures**
Ultraviolet Radiation		
Visible Energy		
Infrared Radiation		
Microwaves and Radio Waves		
Power Transmission		
Radar		
Lasers		

3. Summary

General Safety Interfaces

There are many general safety interfaces that are used to protect workers from common industrial and maintenance operations. Some are listed below.

- Welding — Establish fire protection, fire watches, personnel protection (i.e., railings, eye protection, protective clothing), health protection and ventilation, etc.
- Material handling — Ensure sufficient clearances when using mechanical handling equipment; housekeeping; secure storage; clearance signs; derail and/or bumper blocks on spur railroad tracks; guarding over pits, tanks, vats, ditches; etc.
- Machining — Machine guarding, work rests, repairs and maintenance, engineering design, safety devices, etc.
- Cleaning — Drains and traps, chip guarding, personal protective clothing, ventilation, solvent selection, fire protection, etc.
- Coating — Ventilation, housekeeping, personal protective clothing, fire protection, drying spaces, spray booths, etc.

Placement of Operations and Equipment

The placement of operations activities and the location of equipment is an important safety concern. Sufficient clearances should be ensured when using mechanical handling equipment. Housekeeping must be maintained to ensure access and movement. Storage of material must be secure to maintain clear aisles and passageways. Signs must also be posted that indicate the amount of clearance provided. Structural support must also be adequate to hold necessary equipment and operations.

Machinery Related Hazards

Point of operation hazards exist in machinery at the point at which cutting, shaping, boring, or forming is accomplished on the stock. A machine guard is a barrier that prevents entry of the operator's hands or fingers into the point of operation. There are several OSHA requirements regarding machine guarding. 29 CFR Part 1910.212(a) states that "One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips, and sparks." For more information, refer to the *Machinery and Machine Guarding Surveillance Guide*, prepared by the Oak Ridge Operations Office for the Department of Energy.

Workplace Environmental Hazards

The following matrix identifies possible effects and control measures related to several workplace environmental hazards:

Workplace Environmental Hazards and Control Measures	
Hazard	**Control Measures**
Noise	• Exposure time limitations • Hearing protection • Noise reduction at the source • Noise dampening
Thermal Burns	• Engineering design • Insulation • Guards • Personal protective clothing
Heat Stress	• Acclimatization periods • Work and rest regimens • Distribution of work load with time • Regular breaks • Provision for water intake • Protective clothing • Application of engineering controls
Eye Hazards	• Face shields • Goggles and/or safety glasses • Machine guards • Hand shields • Welding helmets
Illumination	• Auxiliary lighting • Engineering design

Non-Ionizing Radiation Hazards

The following matrix identifies control measures related to non-ionizing radiation hazards.

Non-Ionizing Radiation Hazards and Control Measures		
Radiation Form	**Possible Effects**	**Control Measures**
Ultraviolet Radiation	• Suntan • Sunburn • Eye injury • Cataracts • Decreased skin elasticity • Skin cancer	• Minimize exposure • Eye protection • Skin creams
Visible Energy	• Headaches • Eye fatigue	• Vary amount or type of lighting • Reduce glare
Infrared Radiation	• Increased tissue temperature • Burns • Eye injury	• Minimize exposure • Protective eyewear • Face shields
Microwaves and Radio Waves	• Increased tissue temperature • Burns • Cataracts	• Minimize exposure • Shielding • Door interlocks
Power Transmission	• Circadian Rhythm disruption • Diminished field perception	• Minimize exposure • Shielding
Radar	• Effects of X-ray radiation (if high voltage) • Increased tissue temperature	• Minimize exposure • Periodic medical examinations • Use of microwave absorber
Lasers	• Eye injury • Skin injury	• Minimize exposure • Eye protection

4. Exercise Solutions

EXERCISE 1.12-A Identify at least three general safety interfaces used to protect workers from each of the following common industrial and maintenance operations:

- Welding
- Material handling
- Machining
- Cleaning
- Coating.

ANSWER 1.12-A There are many possible answers for each of these items. Some are listed below. A correct answer will require three items for each operation.

- Welding -- Establish fire protection, fire watches, personnel protection (i.e., railings, eye protection, protective clothing), health protection and ventilation, etc.
- Material handling -- Ensure sufficient clearances when using mechanical handling equipment; housekeeping; secure storage; clearance signs; derail and/or bumper blocks on spur railroad tracks; guarding over pits, tanks, vats, ditches; etc.
- Machining -- Machine guarding, work rests, repairs and maintenance, engineering design, safety devices, etc.
- Cleaning -- drains and traps, chip guarding, personal protective clothing, ventilation, solvent selection, fire protection, etc.
- Coating -- Ventilation, housekeeping, personal protective clothing, fire protection, drying spaces, spray booths, etc.

EXERCISE 1.12-B Describe the safety considerations associated with the placement of operations and equipment.

ANSWER 1.12-B The placement of operations activities and the location of equipment is an important safety concern. Some of the items that should be considered include the following:

- Sufficient clearances should be ensured when using mechanical handling equipment.
- Storage of material must be secure to maintain clear aisles and passageways.
- Signs must also be posted that indicate the amount of clearance

provided.
- Structural support must also be adequate to hold necessary equipment and operations.

EXERCISE 1.12-C What are “point of operation” hazards?

ANSWER 1.12-C Point of operation hazards are defined as hazards that exist in machinery at the point at which cutting, shaping, boring, or forming is accomplished on the stock.

EXERCISE 1.12-D Using 29 CFR Part 1910, Subpart O, define “guard,” as used in machinery, and state the primary general requirement for machine guards.

ANSWER 1.12-D
- A guard is a barrier that prevents entry of the operator's hands or fingers into the point of operation.
- One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips, and sparks.

EXERCISE 1.12-E Using 29 CFR Part 1910, develop a matrix similar to the one shown in Exercise 1.12-E, Self-Study Exercises. Use the matrix to identify control measures related to the following workplace environmental hazards:
- Noise
- Thermal burns
- Heat stress
- Eye hazards
- Workplace illumination

ANSWER 1.12-E

Workplace Environmental Hazards and Control Measures	
Hazard	**Control Measures**
Noise	• Exposure time limitations • Hearing protection • Noise reduction at the source • Noise dampening
Thermal Burns	• Engineering design • Insulation • Guards • Personal protective clothing
Heat Stress	• Acclimatization periods • Work and rest regimens • Distribution of work load with time • Regular breaks • Provision for water intake • Protective clothing • Application of engineering controls
Eye Hazards	• Face shields • Goggles and/or safety glasses • Machine guards • Hand shields • Welding helmets
Illumination	• Auxiliary lighting • Engineering design

EXERCISE 1.12-F Using Chapter 11 of *Fundamentals of Industrial Hygiene*, National Safety Council, or another industrial hygiene-related text that includes content regarding non-ionizing radiation, develop a matrix similar to the one shown in Exercise 1.12-G, Self-Study Exercises. Use the matrix to identify possible effects and control measures related to the following non-ionizing radiation hazards:

- Ultraviolet radiation
- Visible energy
- Infrared radiation
- Microwaves and radio waves
- Power transmission
- Radar
- Lasers

ANSWER 1.12-F

Non-Ionizing Radiation Hazards and Control Measures		
Radiation Form	**Possible Effects**	**Control Measures**
Ultraviolet Radiation	• Suntan • Sunburn • Eye injury • Cataracts • Decreased skin elasticity • Skin cancer	• Minimize exposure • Eye protection • Skin creams
Visible Energy	• Headaches • Eye fatigue	• Vary amount or type of lighting • Reduce glare
Infrared Radiation	• Increased tissue temperature • Burns • Eye injury	• Minimize exposure • Protective eyewear • Face shields
Microwaves and Radio Waves	• Increased tissue temperature • Burns • Cataracts	• Minimize exposure • Shielding • Door interlocks

Non-Ionizing Radiation Hazards and Control Measures		
Radiation Form	**Possible Effects**	**Control Measures**
Power Transmission	• Circadian Rhythm disruption • Diminished field perception	• Minimize exposure • Shielding
Radar	• Effects of X-ray radiation (if high voltage) • Increased tissue temperature	• Minimize exposure • Periodic medical examinations • Use of microwave absorber
Lasers	• Eye injury • Skin injury	• Minimize exposure • Eye protection

Competency 1.13 **Occupational safety personnel shall demonstrate a familiarity level knowledge with the use and function of safety related testing and measurement equipment.**

1. Supporting Knowledge and Skills

a. Discuss the use and function of safety related testing equipment such as oxygen meters, explosive atmosphere meters, electrical test equipment, illumination meters, calipers, etc.

b. Discuss the need for proper equipment maintenance and calibration.

c. Describe the circumstances that would require the use of each type of equipment.

d. Describe appropriate actions taken in response to various readings from each type of equipment.

e. Describe the appropriate application and function of industrial hygiene monitoring and sampling equipment and discuss required safety interfaces.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

EXERCISE 1.13-A Why is knowledge of proper equipment maintenance and calibration important for occupational safety personnel?

EXERCISE 1.13-B Determine what safety equipment and instrumentation is currently in use on your site or at your facility. Locate the operations manuals and any procedures or policies governing the use of the equipment. Review the materials you have found. Complete the following matrix for the primary equipment under your jurisdiction.

Instrument	Purpose or Function	Calibration Interval or Requirement	Example of an Initiating Circumstance	Notes

Use additional space if you have identified more than six instruments.

EXERCISE 1.13-C Select one instrument from the chart you have completed. Describe the circumstances that would require the use of that piece of equipment.

EXERCISE 1.13-D Using the instrument selected for 1.13-C, describe appropriate actions to be taken for two different readings from the instrument. These should be readings that would indicate some action be taken (i.e., not "normal" readings.)

EXERCISE 1.13-E Describe the appropriate application and function of industrial hygiene monitoring and sampling equipment in use at your site or facility and discuss required safety interfaces.

3. Summary

Proper maintenance and use of safety equipment is critical to meeting DOE's mission of protecting the public, workers, and the environment. It is imperative that the instruments be operated, and their data interpreted by qualified individuals who are thoroughly familiar with the particular device's operating principles and limitations, and who have obtained the device's latest operating instructions and calibration data. Instruments should be calibrated according to the manufacturer's instructions and designated times and intervals.

4. Exercise Solutions

EXERCISE 1.13-A Why is knowledge of proper equipment maintenance and calibration important for occupational safety personnel?

ANSWER 1.13-A DOE relies upon the accuracy of equipment and instrument readings to provide a safety envelope for the public, workers, and the environment. Without proper maintenance and calibration, the instrument readings are unreliable and that envelope is compromised.

EXERCISE 1.13-B Determine what safety equipment and instrumentation is currently in use on your site or at your facility. Locate the operations manuals and any procedures or policies governing the use of the equipment. Review the materials you have found. Complete the following matrix for the primary equipment under your jurisdiction.

ANSWER 1.13-B Note: The following are provided as examples of typical equipment and requirements. Your answers may vary.

Instrument	Purpose or Function	Calibration Interval or Requirement	Example of an Initiating Circumstance	Notes
Oxygen Meter	Measures the percentage of O_2 in the air.	Must be calibrated prior to use to compensate for altitude and barometric pressure.	Need to identify oxygen-deficient environment, or flammable or explosive atmosphere.	All critical readings are dependent upon the environment and the process. You should be familiar with the critical readings for all instruments in the situations in which they are used on your site.
Combustible Gas Indicator (CGI)	Measures the concentration of a combustible gas or vapor.	Accuracy depends, in part, on the difference between the calibration and sampling temperatures. Calibrate immediately before use.	Formation of combustible gases (i.e., hydrogen-oxygen) as a result of a process.	
Illumination Meter	Measures three essential quantities: illumination, luminance, and reflectance.	Instruments should be corrected (to account for light reflected from the light-detecting cell surface), calibrated for accuracy and with scale ranges so that measurements are made below one-quarter full scale.	There is some question as to whether a work area is adequately lighted.	

EXERCISE 1.13-C Select one instrument from the chart you have completed. Describe the circumstances that would require the use of that piece of equipment.

ANSWER 1.13-C This is dependent upon the instrument selected. Review the appropriate procedures or operations manuals to verify your answer.

EXERCISE 1.13-D Using the instrument selected for 1.13-C, describe appropriate actions to be taken for two different readings from the instrument. These should be readings that would indicate some action be taken (i.e. not “normal” readings.)

ANSWER 1.13-D This is dependent upon instrument selected. Review the appropriate procedures or operations manuals to verify your answer.

EXERCISE 1.13-E Describe the appropriate application and function of industrial hygiene monitoring and sampling equipment in use at your site or facility and discuss required safety interfaces.

ANSWER 1.13-E This is also dependent upon instruments in use at your facility or site. Review the appropriate procedures or operations manuals to verify your answer.

Competency 1.14 **Occupational safety personnel shall demonstrate a working level knowledge of safety in the research and development, manufacture, use, transportation, testing, demilitarization, and disposal of explosives.**

1. Supporting Knowledge and Skills

a. Discuss the hazards associated with explosive material in terms of blast overpressure, fragments, thermal burns, and toxicity.

b. Identify the hazard classification of explosives and discuss the storage and compatibility requirements for each classification.

c. Discuss the major principles of personnel protection from explosives hazards and describe the application of each of these principles to explosives operations.

d. Describe the types, purpose, and application of personal protective clothing and equipment for explosives operations.

e. Discuss and demonstrate the ability to apply quantity-distance criteria to explosives operations.

f. Discuss the hazards associated with electrical equipment and installations in or near explosives operation and describe required control measures including appropriate hazard classifications.

g. Discuss the hazards associated with uncontrolled electrical sources such as static electricity and lightning, and describe the application of required controls such as:
   - Lightning protection
   - Non-sparking tools
   - Conductive footwear and floors
   - Equipment bonding and grounding

h. Discuss fire protection considerations for explosives operations.

i. Describe the role of hazard analysis and planning techniques for designing or evaluating explosives operations.

j. Discuss the proper facility design features for Department of Energy explosives operations.

k. Discuss the importance of the development, implementation, and maintenance of safe work procedures for explosives operations.

l. Discuss range safety considerations including required procedures and controls.

m. Describe the necessary precautions and procedures related to transportation of explosives.

2. Self-Study Activities (corresponding to the intent of the above competency)

NOTE: Below are three web sites containing many of the references you may need.

Web Sites		
Organization	**Site Location**	**Notes**
Department of Energy	http://cted.inel.gov/cted/index.html	DOE Standards, Guides, and Orders.
OSHA	http://www.osha-slc.gov/	OSHA documents and search engine
U.S. House of Representatives	http://law.house.gov/cfr.htm	Searchable Code of Federal Regulations

Read DOE Order 5480.16A, *Firearms Safety*, Chapter IV.

Review DOE/EV/06194, Revision 7, *DOE Explosives Safety Manual.*

Read 29 CFR 1926, Subpart U, "Blasting and the Use of Explosives."

EXERCISE 1.14-A Discuss the toxicity hazards associated with explosive material.

Read 49 CFR 173.2, "Hazardous Materials Classes and Index to Hazard Class Identification."

EXERCISE 1.14-B Identify the explosives classes and divisions.

EXERCISE 1.14-C What is the maximum quantity of explosives (in pounds) that can be stored in a Class II magazine?

EXERCISE 1.14-D What is the American Table of Distances (a.k.a. Quantity Distance Tables) as relates to explosives?

EXERCISE 1.14-E Two major principles of explosives safety are limitation and control. What personnel and explosives limits does the *DOE Explosives Safety Manual* provide? You may use the manual as a reference.

Read OSHA *Technical Manual*, 2nd Edition, p. 12-7.

EXERCISE 1.14-F What type of full-body protective clothing is recommended by OSHA for use in a potentially explosive situation?

EXERCISE 1.14-G Using the *DOE Explosives Safety Manual* as a reference, give the formula for establishing the safe separation distance, and explain each factor.

EXERCISE 1.14-H Discuss the hazards associated with electrical equipment and installations in or near explosives operation and describe required control measures including appropriate hazard classifications.

EXERCISE 1.14-I Using the *DOE Explosives Safety Manual* as a reference, state the guidelines that govern shutdown of operations during an electrical storm.

EXERCISE 1.14-J Using the *DOE Explosives Safety Manual* as a reference, what is the minimum firebreak required around aboveground magazines or facilities processing or containing explosives?

EXERCISE 1.14-K According to the *DOE Explosives Safety Manual,* what are the three elements of hazard identification and communication that managers are required to complete before beginning explosives operations?

EXERCISE 1.14-L What does the *DOE Explosives Safety Manual* direct when using revolving doors as a means of escape from an explosives area?

EXERCISE 1.14-M When are explosives operating procedures required?

EXERCISE 1.14-N Explain why explosives safety procedures are required by the *DOE Explosives Safety Manual*.

EXERCISE 1.14-O What information does the *DOE Explosives Safety Manual* provide about hearing damage control during test firing, under the heading of "General Range Standards?"

Read DOE Order 1540.2, *Hazardous Material Packaging for Transport - Administrative Procedures*, Chapter XI, "Explosives Classifications."

EXERCISE 1.14-P Using the *DOE Explosives Safety Manual*, determine the minimum safe distance in feet between a UHF radiative power transmitter of 10,000 watts and electrical blasting operations.

EXERCISE 1.14-Q Using DOE Order 1540.2 as a reference, state the three requirements for transportation of new explosives.

3. Summary

Explosives present a potentially significant hazard to the public and DOE personnel if they are not handled and transported safely. Therefore, significant restrictions exist for the manufacture, storage, use, transportation, and disposal of explosives, and several agencies have regulations governing them. As a general rule, the key is to minimize the quantities of explosives and the personnel exposed to them while maximizing the distances from the danger and the escape options.

Several general provisions apply to any activity where explosive safety is a concern.

1. Only authorized and qualified persons should be allowed to handle and use explosives.
2. Any device capable of producing flame, head, or sparks is prohibited in or near explosives, or explosive storage areas.
3. No person is allowed to handle or use explosives while under the influence of intoxicating liquors, narcotics, or other dangerous drugs.
4. All explosives must be accounted for at all times and may not be abandoned.
5. No fire may be fought where the fire is in imminent danger of contact with explosives. (While fire is an obvious threat when dealing with explosives, it is important to remember that most accidental detonation of explosives result from stimuli other than fire.)
6. Blast containment precautions are required in congested areas, or in proximity to a structure or installation that might be damaged.
7. Every reasonable precaution including visual and audible warning signals, flags, and barricades must be used to ensure employee safety.
8. Blasting operations above ground should be conducted between sunup and sundown.

9. Precautions must be taken to prevent accidental discharge of electric blasting caps from induced current.
10. Packing materials previously containing high explosives must be burned at an approved location and not reused.
11. Buildings used for mixing blasting agents must meet particular specifications.

DOE adopted the hazard classification system recommended by the United Nations Organization (UNO), which defines types and severities of hazards for explosives. This system consists of nine classes for dangerous goods, with explosives in Class 1. This class further subdivides into divisions based on the character and predominance of the associated hazards, and the predominance of the associated hazards.

4. Exercise Solutions

EXERCISE 1.14-A Discuss the toxicity hazards associated with explosive material.

ANSWER 1.14-A Explosives materials, components, and materials used in explosives processing can be toxic when inhaled, ingested, or absorbed through the air. Skin contact can result in a skin rash, the most common effect from working with these materials. The *DOE Explosives Safety Manual* contains some precautions to minimize these hazards. These include good ventilation, protective clothing, and good personal hygiene practices.

EXERCISE 1.14-B Identify the explosives classes and divisions.

ANSWER 1.14-B

Explosives Classes and Divisions		
Class No.	**Division No. (if any)**	**Name of Class or Division**
None	.....	Forbidden explosives
1	1.1	Explosives (with a mass explosion hazard)
1	1.2	Explosives (with a projection hazard)
1	1.3	Explosives (with predominately a fire hazard)

Explosives Classes and Divisions		
Class No.	**Division No. (if any)**	**Name of Class or Division**
1	1.4	Explosives (with no significant blast hazard)
1	1.5	Very insensitive explosives; blasting agents
1	1.6	Extremely insensitive detonating substances

EXERCISE 1.14-C What is the maximum quantity of explosives (in pounds) that can be stored in a Class II magazine?

ANSWER 1.14-C The maximum quantity of explosives that can be stored in a Class II magazine is 50 pounds.

EXERCISE 1.14-D What is the American Table of Distances (a.k.a. Quantity Distance Tables) as relates to explosives?

ANSWER 1.14-D The American Table of Distances refers to the American Table of Distances for Storage of Explosives as revised and approved by the Institute of the Makers of Explosives, June 5, 1964. It provides the acceptable distances in feet when storage is barricaded for separation of explosive magazines.

EXERCISE 1.14-E Two major principles of explosives safety are limitation and control. What does the *DOE Explosives Safety Manual* say about personnel and explosives limits? You may use the manual as a reference.

ANSWER 1.14-E "1. Explosives Limits: The quantity of explosives at an operating location shall be the minimum necessary to carry out the operation in a safe and efficient manner. When practical, this quantity shall be subdivided and adequately separated to prevent propagation of detonation. Supplies exceeding this minimum quantity shall be removed from the operating area.

In no case shall the quantity of explosives permitted in an operating building exceed the maximum permitted by the quantity-distance

criteria. . . .

2. Personnel Limits: The number of personnel at an operating location shall be the minimum consistent with safe and efficient operation. In establishing personnel limits, the following principles shall be followed.

a. Jobs not necessary to the performance of a hazardous explosives operation should not be performed in the same location as the hazardous operation. Personnel not needed for the hazardous operations will not be allowed in hazardous locations.
b. Personnel limits shall allow for necessary casuals.
c. Sufficient personnel shall be available to perform a hazardous operation safely and, in the event of accident, to obtain help and aid the injured.
d. No person shall work alone performing explosives activities that have a high risk of serious injury. Prompt and easy communications with other employees shall be provided. Facility management shall specify which explosives activities may be performed alone." Chapter III, 1. & 2.

EXERCISE 1.14-F What type of full-body protective clothing is recommended by OSHA for use in a potentially explosive situation?

ANSWER 1.14-F Blast and fragmentation suits, vests, and clothing may be used in conjunction with bomb blankets and bomb carriers to reduce the dangers in very small detonations. They will not provide for hearing protection.
(OSHA, *Technical Manual,* 2nd Edition, p. 12-7)

EXERCISE 1.14-G Using the *DOE Explosives Safety Manual* as a reference, give the formula for establishing the safe separation distance, and explain each factor.

ANSWER 1.14-G The formula is $D=KW^{1/3}$

- D is the distance in feet.
- K is a factor depending upon the risk assumed or permitted.
- W is the NEW (Net Explosive Weight) in pounds.

EXERCISE 1.14-H Discuss the hazards associated with electrical equipment and installations in or near explosives operation.

ANSWER 1.14-H Electrical equipment and installations provide many sources for concern when explosives are present. There is the danger of electrical sparks; short-circuits due to water infiltration, physical damage to the wiring, or exposed conductors or connectors; excessive surface temperature on electrical devices; and failure of electrical service lines.

EXERCISE 1.14-I Using the *DOE Explosives Safety Manual* as a reference, state the guidelines that govern shutdown of operations during an electrical storm.

ANSWER 1.14-I "The following guidelines should be used for shutdown of an operation during an electrical storm:

a. Process equipment containing explosives should be stopped as soon as safety permits.
b. When buildings or bays containing explosives are evacuated during periods of electrical storms, operations that cannot be shut down immediately should be manned by the minimum number of personnel required for safe shutdown. When the operation has been brought to a safe condition so that personnel can exit, evacuation of these remaining personnel should proceed.
c. Automatic emergency power equipment should be provided if electrical power is critical to an explosives operation during a power shutdown or interruption." Chapter II, 6.3.

EXERCISE 1.14-J Using the *DOE Explosives Safety Manual* as a reference, what is the minimum firebreak required around aboveground magazines or facilities processing or containing explosives?

ANSWER 1.14-J "A fire break at least 15 meters wide and free from combustible material should be maintained around each aboveground magazine or facility processing or containing explosives." Chapter VI, 5.1.

EXERCISE 1.14-K According to the *DOE Explosives Safety Manual*, what are the three elements of hazard identification and communication that managers are required to complete before beginning explosives operations?

ANSWER 1.14-K "Before beginning explosives operations, managers shall
a. Identify and maintain a current list of explosives and other hazardous material used in conjunction with their operations.
b. Determine the hazardous properties and toxicity of these materials through the use of the manufacturer's Material Safety Data Sheets (MSDS) or other information sources and through consultation with the facility industrial hygiene staff. For explosives without published toxicological data, guidance can be obtained through the DOE Toxic Materials Advisory Committee (TMAC). Health hazard information must be communicated to employees who work with or generate hazardous materials.
c. Educate and train employees in the hazards and precautions required for handling explosives and materials used in conjunction with explosives operations. This training should be part of the employee training and qualification program specified in Chapter V." Chapter II, 1.6.

EXERCISE 1.14-L What does the *DOE Explosives Safety Manual* direct when using revolving doors as a means of escape from an explosives area?

ANSWER 1.14-L "A revolving door is acceptable if a secondary means of escape (with swinging doors) is provided at the same location. The revolving door must also be prevented from rotating at too rapid a rate in order to permit orderly exit of personnel." Chapter II, 2.2.6.c.

EXERCISE 1.14-M When are explosives operating procedures required?

ANSWER 1.14-M According to the *DOE Explosives Safety Manual*, "Before starting any operation involving explosives, operating procedures shall be written and approved." Chapter VII, 2.1.

EXERCISE 1.14-N Explain why explosives safety procedures are required by the *DOE Explosives Safety Manual*.

ANSWER 1.14-N "These requirements for procedures minimize the chances of an incident resulting from operations using outdated, inapplicable, or incomplete procedures, or from operations performed in violation of established practices." Chapter VII, 1.1.

EXERCISE 1.14-O What information does the *DOE Explosives Safety Manual* provide about hearing damage control during test firing, under the heading of "General Range Standards?"

ANSWER 1.14-O "Detonation of very large explosive shots, numerous smaller shots, or gun firings may result in hearing damage and may exceed the DOE allowable limits for impulse noise. Make a noise evaluation of these activities to ensure that adequate hearing protection is provided to those involved." Chapter II, 13.3.1.f.

EXERCISE 1.14-P Using the *DOE Explosives Safety Manual*, determine the minimum safe distance in feet between a UHF radiative power transmitter of 10,000 watts and electrical blasting operations.

ANSWER 1.14-P The safe distance is 600 feet. Chapter II, 13.3.5, Table II-2.

EXERCISE 1.14-Q Using DOE Order 1540.2 as a reference, state the three requirements for transportation of new explosives.

ANSWER 1.14-Q "New explosives, including explosive compounds, mixtures, or devices (hereinafter referred to as explosives) may be transported if they have been examined, classified, and approved for shipment by DOE." DOE 1540.2, Chapter XI, 2.a.